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Prospects for the use of *Poterium polygamum* Waldst. et Kit. as a biological growth stimulant in animals

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ABSTRACT

The relevance of the conducted research lies in the need to diversify the fodder base of livestock production, in particular through the introduction of *Poterium polygamum* Waldst. et Kit. into organic fodder production, as this species contains biologically active compounds that act as natural animal growth stimulants. The aim of the study was to experimentally determine the suitability of this species for use as a component of organic feed additives, its technological suitability when grown in pure stands, and its potential for producing dry raw material. The research employed field, laboratory, analytical, and statistical methods. Low effectiveness of overseeding *Poterium polygamum* into grass stands on drained peat soils was established. In contrast, high technological suitability of the species was proven on typical chernozem soils of the left-bank Forest-Steppe, manifested in its ability to maintain weed-free stands due to the allelopathic activity of the root system, which is of exceptional importance for crop management and energy saving. Long-term studies demonstrated yield stability of *Poterium polygamum*, with an average fresh biomass yield of 11.7 t ha^{-1}, ranging from 9.4 to 15.5 t ha^{-1}, and an average dry matter yield of 3.2 t ha^{-1}, varying from 2.3 to 4.6 t ha^{-1}, which is sufficient for its inclusion in organic feed additives. The value of *Poterium polygamum* for organic fodder production is determined by the presence of biologically active compounds (flavonoids, tannins, saponins, etc.). The species also exhibits high feed nutritive value and good palatability, indicating its high potential for inclusion in phytomixtures for animal feeding. In addition, a database has been developed on sowing dates and methods, as well as optimal harvesting periods, enabling its effective use in organic fodder production. The inclusion of this plant in animal diets can contribute to the production of organic livestock products in compliance with the objectives of the European Green Deal strategy.

Keywords: medicinal and fodder species, yield, chemical composition, technological suitability, phytomixtures, biologically active compounds, raw material, sowing and harvesting periods.

INTRODUCTION

Modern fodder production practices in Ukraine and the European Union indicate that grass and legume species are the most suitable among perennial forage crops. In the Polissia, Forest-Steppe, and Carpathian regions, the most commonly used grass species include *Phleum pratense* L., *Bromus inermis* Leyss., *Dactylis glomerata* L., *Lolium perenne* L., and *Lolium pratense* (Huds.) Darbysh., while among Fabaceae the most widely cultivated species are *Trifolium pratense* L., *Trifolium repens* L., *Medicago sativa* L., *Medicago falcata* L., *Lotus corniculatus* L., and several other less common species used in fodder production. For these species, cultivation technologies have been developed for different soil and climatic zones (Kurgak et al., 2020; Kaminskyi et al., 2021; Karbivska et al., 2022). Grass and legume forage species are characterized by high productivity and high feed nutritional value, and they almost completely meet

the nutritional requirements of livestock during the grazing period, while also forming a substantial part of animal diets during the winter housing period (Panakhyd et al., 2017; Bogovin and Ptashnyk, 2020).

However, in recent decades, in order to further increase the productivity of farm animals, artificial growth stimulants (premixes) have been increasingly incorporated into animal diets. This practice has enabled producers to achieve rapid weight gain and significantly reduce fattening periods. In addition, antibiotics such as flavomycin, biolyt, bacitracin, and others have been widely used to enhance animal productivity. Due to restrictions on the use of antibiotics, since 2006 animal feeding systems have increasingly relied on feed enzymes, probiotics, feed acidifiers, and similar additives (Maystrenko et al., 2020; Poberezhets, 2021; Prudius and Vishchur, 2022). However, although the application of premixes, even in small amounts, produces a positive physiological effect, it has been shown that their use in animal feeding entails not only economic benefits but also adverse effects on animal and human health. As a consequence, the agricultural sector has faced livestock populations with impaired immune system status and reduced genetic potential (Nazarchuk, 2023). Therefore, human consumption of livestock products containing excessive amounts of artificial growth stimulants, particularly those based on antibiotics and hormones, leads to severe negative outcomes associated with the development of resistance to these substances and a decline in immune function in both animals and humans (Kryzhak et al., 2020; Chudak et al., 2021).

In response to these challenges, the European Commission adopted the European Green Deal in December 2019, with the primary objective of significantly improving the quality and sustainability of agricultural products. In this context, medicinal and fodder herbs have been explored as natural alternatives to artificial animal growth stimulants, taking into account their proven effectiveness in veterinary medicine as sources of biologically active compounds for the treatment and prevention of animal diseases (Moisiienko, 2020; Nazarchuk, 2023). This research direction is relatively new and remains insufficiently studied. However, previous studies have demonstrated the effectiveness of Echinacea purpurea, particularly in pig production, based on research conducted at the Institute of Pig Breeding of the National Academy of Agrarian Sciences of Ukraine, as well as in aquaculture at the Institute of Fisheries of the NAAS. Noteworthy results were also reported by Chudak et al. (2020) regarding the effectiveness of *Echinacea pallida* in poultry feeding (quails) at Vinnytsia National University.

Available sources on global practices of using medicinal plants as phytobiotics provide extremely limited information. Therefore, an important task is the identification of plant species with a high content of biologically active compounds (BACs) suitable for use in fodder production as alternatives to artificial growth stimulants in animal feeding. In recent years, the potential inclusion of medicinal plants in animal feeds has become a subject of scientific investigation (De Falco et al., 2019; Prudius and Vishchur, 2022). However, the feasibility of such substitution, the range of promising plant species, the content of biologically active compounds (essential oils, flavonoids, organic acids, polysaccharides, and others), as well as appropriate application doses for specific livestock species, remain insufficiently studied for broad practical implementation.

One of the possible approaches to utilizing such plant species is their inclusion in sown forage grass stands, incorporating medicinal plants such as *Achillea millefolium* L., *Taraxacum officinale* (L.) Weber ex F.H. Wigg., *Cichorium intybus* L., *Origanum vulgare* L., among others (Kurhak et al., 2022; Shtakal et al., 2024). However, this approach is currently problematic due to the inability to accurately determine the dosage (proportion) of medicinal and fodder herbs within grass–legume swards, as their content varies between years and cuts and depends on weather conditions and other important environmental factors. Despite these limitations, such studies have considerable potential for practical application; therefore, the search for promising plant species should be continued, along with the improvement of cultivation technologies aimed at their use in livestock production and in the feeding of various farm animal species.

Based on experimental studies, the feasibility of cultivating medicinal and fodder plants in pure stands with subsequent production of feed additives (phytomixtures) for animal feeding has been demonstrated (Moisiienko, 2020). At present, a list of major plant species suitable for effective use in fodder production has been established (Chornolata et al., 2021; Shtakal et al., 2023).

However, the potential use of *Poterium polygamum* for this purpose, as a valuable species

rich in biologically active compounds, remains insufficiently studied.

Therefore, this study aimed to assess the suitability of *Poterium polygamum* for the production of organic feed additives as a biological growth promoter in animal production.

MATERIALS AND METHODS

Field experiments were conducted in a stationary trial on typical chernozem soils at the Panfil Research Station of the National Scientific Center "Institute of Agriculture of the National Academy of Agrarian Sciences of Ukraine" during 2021–2025. The typical chernozems formed on light loam were characterized in the plough layer by the following physical and agrochemical properties: humus content 3.08–3.15%; available phosphorus 237–270 mg·kg^{-1}; available potassium 80–100 mg·kg^{-1}; salt pH 5.7; base saturation of the soil adsorption complex 85–99%; hydrolytic acidity 2.1 cmol(+)\·kg^{-1}; and bulk density 1.18 g·cm^{-3}. The experimental plot area was 10 m^2, and the experiment was arranged in four replications.

Poterium polygamum is officially authorized for use in the European Union under Regulation (EC) No. 1831/2003 "Feed additives for use in animal nutrition" (Community Register of Feed Additives pursuant to Regulation (EC) No. 1831/2003). The seeding rate under wide-row sowing with a row spacing of 45 cm was 17 kg·ha^{-1} of viable seed. Sowing was performed using a manual seeder in the first decade of May under a cover crop of *Coriandrum sativum* L.

To evaluate the effectiveness of undersowing *Poterium polygamum* into old-established grasslands, studies were conducted on drained peat soils of the floodplain of the Supii River. The peat layer depth exceeded 2 m. The upper soil layer (0–30 cm) was characterized by the following agrophysical and agrochemical properties: degree of peat decomposition >80%; ash content 45–50%; bulk density 0.35–0.40 g·cm^{-3}; water pH 7.5–7.7; total nitrogen content 1.6–2.0%; available phosphorus 0.30–0.40%; available potassium 0.10–0.15%; and high-molecular-weight organic acids 15–16%. The results reported by other authors demonstrate the potential for its cultivation across a range of soil and climatic conditions in Ukraine (Grodzinsky et al., 1990; Puiu, 2015; Puiu, 2016). When crops were grown in pure stands, no mineral fertilizers were applied, as this would contradict the principles of organic farming. Crop management included a single inter-row cultivation for weed control in the second year of vegetation, while in subsequent years inter-row cultivation was carried out to conserve soil moisture. Weather conditions during the growing seasons were characterized by air temperatures exceeding long-term averages by 0.9–3.9 °C and by prolonged drought periods, particularly in August–September and throughout 2024.

Harvesting was performed once per growing season. All measurements and observations of plant growth and development were conducted in accordance with the methodology of the Institute of Forage and Podillia of the NAAS (Babych et al., 1998). Dry matter content in fresh green biomass was determined using the oven-drying gravimetric method at 105 °C. Comprehensive zootechnical analysis, in vitro feed digestibility, and mineral element content were determined in accordance with DSTU 4117:2007 using infrared spectrometry with appropriate software. The content of biologically active compounds in air-dried raw material was determined using methods specified in the State Pharmacopoeia of Ukraine and the European Pharmacopoeia (European Pharmacopoeia, 2010; State Pharmacopoeia of Ukraine, 2015). Statistical analysis of the field experiment data was performed using analysis of variance (ANOVA) with Microsoft Excel software, following Yeshchenko et al. (2014).

RESULTS AND DISCUSSION

One of the valuable and promising crops for organic fodder production is *Poterium polygamum*, a species belonging to the family Rosaceae. This crop is, without exaggeration, practically not involved in applied fodder production and remains largely unfamiliar to practitioners as well as to many specialists in the field. A strong confirmation of this is the absence of *P. polygamum* from the lists of zoned forage and agricultural crop varieties and from the official Registers of Plant Varieties Approved for Distribution in Ukraine in recent years (Protection of Rights to Varieties, Ukrainian Institute of Plant Variety Examination, Issue 6, 2021).

According to recent botanical syntheses on the diversity of vascular plants of Ukraine, two

species of the genus *Poterium* L. occur in the country: *Poterium sanguisorba* L. and *Poterium polygamum* Waldst. et Kit. (Mosyakin and Fedoronchuk, 1999). These species are undemanding with respect to growing conditions and cultivation practices. Their chemical composition is relatively rich and diverse; however, it remains insufficiently studied for applications in human medicine and veterinary science, and especially for use in organic fodder production.

Poterium polygamum is characterized by a taproot system and an erect, glabrous stem. Its well-developed root system enables the plant to withstand drought periods and to produce high yields of green biomass and high-quality seed during post-stress recovery. The stems are branched, densely leafy, and reach a height of 40–80 cm. Leaves are pinnate, borne on relatively long petioles, and are yellowish- to glaucous-green in color. The flowers are small, greenish, and arranged in dense, ellipsoid, capitate inflorescences; they are monoecious and unisexual. Pistillate flowers are located in the upper part of the inflorescence, staminate flowers in the lower part, and bisexual flowers occur in the middle, each with two scaly bracts at the base. The fruits are nutlets, ovoid, ribbed, and brown in color. The thousand-seed weight ranges from 8 to 10 g.

To address the objectives of producing organic feed additives with a high content of biologically active compounds, two main approaches can be applied: (i) the inclusion of medicinal fodder plants in grass–legume mixtures, or (ii) their cultivation in pure stands followed by incorporation into animal feeding rations.

When *Poterium polygamum* was included in grass mixtures, field experiments were conducted during 2021–2025 on drained deep peat soils of the Supii River floodplain (plot No. 3 of the Panfil Research Station of the National Scientific Center "Institute of Agriculture of the NAAS"). Yield data indicated that on peat soils the productivity of grass stands during 2021–2025 ranged from 24.1 to 25.4 t·ha^{-1} of fresh biomass and from 6.34 to 6.58 t·ha^{-1} of air-dried matter (Table 1). However, yield increases resulting from the inclusion of medicinal and fodder plants in the mixtures were not statistically significant.

Long-term studies showed that when medicinal species were introduced into old-established grass stands at a rate of 7% of the standard seeding rate, their actual proportion in the sward on drained peat soils was relatively low: *Taraxacum officinale* reached a substantial share of 4.0%, whereas *Poterium polygamum* accounted for only 1.3%. This can be attributed to elevated groundwater levels during the spring season, which lead to root system dieback as a result of waterlogging. Therefore, for achieving positive outcomes, it is recommended to select well-drained peat soils characterized by a stable water regime.

These findings further indicate that the technology of undersowing medicinal herbs into grass swards requires refinement and should be implemented on well-drained soils. In contrast, a considerably more promising strategy for the use of medicinal and forage plants in organic meadow fodder production is their cultivation in pure stands, followed by the formulation of phytomixtures based on the obtained plant biomass.

To assess the prospects of using *Poterium polygamum* in organic fodder production on typical chernozem soils, its high technological suitability was demonstrated. As *P. polygamum* is characterized by a winter-type development cycle, undersowing was carried out in the first decade of May into rows of annual medicinal plants (e.g., *Coriandrum sativum*, *Dracocephalum moldavica* L., etc.). After harvesting the cover crop, plant residues were removed from the field. In the following year, a single inter-row cultivation was performed, as *P. polygamum* developed intensively and effectively suppressed weed growth and spread. In subsequent years, only one inter-row soil cultivation aimed at moisture conservation was sufficient, since weeds were practically absent in the crops.

As a result, a unique ability of *P. polygamum* to inhibit weed infestation in its stands was identified, which can be explained by the phenomenon of allelopathy—one of the most important forms of chemical interaction among plants within a phytocoenosis and a key factor determining species composition, population density, structure, and productivity of plant communities. Allelopathic interactions are driven by the release of chemical metabolites into the environment, referred to as phytoncides, biolins, phytolins, or most commonly, colins. This theory was further developed by Grodzinsky (1990), who demonstrated that the quantity and composition of released compounds, and consequently the degree of allelopathic activity, depend on plant species, cultivar, organ, developmental stage, physiological condition, and environmental growing conditions. At the same time, it has been established

Table 1. Yield of grass stands and proportion of medicinal plants (mean for 2021–2025)

Grass stand variant	Fresh biomass yield (t ha^{-1})	Dry matter yield (t ha^{-1})	Share of grasses (%)	Share of medicinal species (%)
Grass mixture (control)	24.1	6.43	75	0
Control + *Silybum marianum*	24.3	6.39	78	0
Control + *Coriandrum sativum*	24.8	6.34	77	0.3
Control + *Taraxacum officinale*	25.4	6.58	76	4.0
Control + *Poterium polygamum*	24.5	6.40	76	1.3

Note: Values are means for 2021–2025; $LSD_{0.05}$ for fresh biomass yield = 0.42 t ha^{-1}.

that this ability is most pronounced in plants with a high content of biologically active ingredients, primarily those species traditionally used as medicinal plants. Therefore, this characteristic of *P. polygamum* is of exceptional importance for organic crop production, as it ensures crop cleanliness as a key component of cultivation technology, contributing significantly to energy saving.

As a perennial plant, *Poterium polygamum* has been cultivated in our experiments for five consecutive years and has consistently provided high yields. Considering the above-mentioned aspects, it is advisable to grow this species outside conventional crop rotations. The effects of its root exudates have been well documented for segetal vegetation and have been shown to exert a suppressive effect. However, its use as a preceding crop for other agricultural crops, including forage species, still requires further investigation.

It was established that in the second year of vegetation *Poterium polygamum* exhibits intensive growth and development, passes through all phenological stages, and reaches mowing maturity for raw material harvesting during the flowering phase, which under long-term use of the stands is observed mainly in the second half of May. An important indicator for assessing the technological suitability of a fodder crop is plant height, as it is a determining factor in weed competition during the growing season and in the feasibility of mechanized harvesting with minimal losses. The height of *P. polygamum* plants during the study years ranged from 58 to 65 cm. Despite this relatively moderate height, the plants successfully competed with weeds and effectively prevented their spread within the sward. At the same time, plant height was suitable for mechanized harvesting.

Long-term studies demonstrated yield stability over the years. Average productivity amounted to 11.7 t·ha^{-1} of fresh green biomass, with annual variation ranging from 9.4 to 15.5 t·ha^{-1}, and 3.2 t·ha^{-1} of dry matter, varying between 2.3 and 4.6 t·ha^{-1} (Table 2). The productivity of *Poterium polygamum* is provided only by the first cut. Under the conditions of the left-bank Forest-Steppe, starting from June (seed maturation phase), the plants remain in a rosette state, which does not allow full-scale mowing; however, weed infestation in the stands is absent. In contrast, under the conditions of the western Forest-Steppe, where the climate is characterized by higher precipitation during the growing season and lower mean annual air temperatures in summer, *P. polygamum* is capable of producing 4–5 cuts with a dry matter yield of up to 5.7 t·ha^{-1} (Puiu, 2015).

In addition, the crop is characterized by a high crude protein content in dry matter. Chemical composition data indicate that, in terms of nutritional value, *P. polygamum* is comparable to grass–legume forage species, with a crude protein content of 15.2%. For other chemical composition parameters, the dry matter of *P. polygamum* is similar to that of grass–legume species.

Table 2. Yield and feed quality of *Poterium polygamum* (2022–2025)

Year	Fresh biomass yield (t ha^{-1})	Dry matter yield (t ha^{-1})	Crude protein (%)	Crude fat (%)	Crude fiber (%)	NFE (%)	Ash (%)	Digestibility (%)
2022	11.5	2.7	15.2	3.5	22.9	49.9	8.5	55.9
2023	15.5	4.6	15.2	3.5	22.9	49.9	8.5	55.9
2024	9.4	2.3	15.2	3.5	22.9	49.9	8.5	55.9
2025	10.4	3.3	15.2	3.5	22.9	49.9	8.5	55.9

Note: NFE – nitrogen-free extract. Values are means of laboratory analyses.

In particular, crude fiber content averaged 22.9%, while nitrogen-free extract (NFE) accounted for 49.9%, indicating a sufficient supply of essential minerals (calcium, phosphorus, and potassium) and good feed digestibility (55.9%), as well as an elevated crude fat content (3.7%). The levels of all controlled agronomically valuable components were consistently high and exhibited only slight fluctuations depending on annual weather conditions. These nutritional characteristics should be taken into account when formulating livestock rations, although the proportion of *P. polygamum* in organic feed additives is relatively small (20–80 g).

The studies demonstrated that the value of *Poterium polygamum* for organic fodder production lies not only in its nutritional properties but also in its health-promoting effects on livestock due to the presence of biologically active compounds. According to our investigations conducted at the Research Station of Medicinal Plants of the Institute of Agroecology and Environmental Management of the NAAS, the air-dried raw material of *P. polygamum* contained flavonoids, expressed as quercetin equivalents, at an average level of 2.85–3.24% during 2023–2024. The content of tannins ranged from 14.0 to 14.5%, while saponins, expressed as ursolic acid equivalents, amounted to 4.8%. In addition, triterpenoids, alkaloids, and fatty acids were detected in the aboveground parts of the plant. Thus, the obtained experimental data confirm the high value and promising potential of *P. polygamum* for use in fodder production.

Thus, the uniqueness of the present research lies in the fact that, for the first time, the methodological basis for the application of medicinal and fodder herbs, including *Poterium polygamum*, in organic fodder production is founded on the principle that medicinal plants, when used at established doses in veterinary medicine, provide a therapeutic effect (Moisiienko, 2020), whereas at reduced doses they exert a stimulatory effect (Zubova and Hrachov, 2021). In particular, our studies demonstrated a positive effect of phytomixtures formulated from selected medicinal and fodder plant species on the productivity of dairy cattle herds and confirmed their suitability for the production of organic meat and dairy products (Shtakal et al., 2022), as supported by patents related to sheep fattening.

With regard to *Poterium polygamum*, its value for fodder production in Ukraine has been investigated mainly at the Kamianets-Podilskyi State Agrarian and Technical University of the Ministry of Education and Science of Ukraine (Puiu, 2016). In those studies, the crop was cultivated exclusively in mixtures with *Onobrychis viciifolia* Scop. as feed for sheep. Given the ongoing decline in sheep numbers in Ukraine, the practical significance of such studies for fodder production has diminished. Moreover, these investigations did not aim to cultivate *P. polygamum* for the formulation of phytomixtures as feed additives, nor did they assess its technological suitability for use not only in sheep feeding but also in the feeding of other farm animal species. The originality of the present study is further enhanced by the fact that it is the first to comprehensively evaluate the nutritional value and chemical composition of *P. polygamum*, particularly its content of biologically active compounds such as flavonoids, tannins, saponins, and related constituents.

A phytomixture composed of medicinal and forage plants including *Poterium polygamum* was tested in sheep fattening, and the effectiveness of this approach was confirmed by Shtakal et al. (2025). The average daily live weight gain of fattening sheep reached 23%. Positive results were also obtained during the testing of organic feed additives containing *Poterium polygamum* in pig fattening, and a patent application has been submitted to UkrNOIVI. These findings indicate the high value of this crop for use in the formulation of organic feed additives as a source of biologically active compounds (flavonoids, organic acids, tannins, and others). It has been demonstrated that *Poterium polygamum*, in combination with other medicinal and forage plants containing polysaccharides, essential oils, and bitter compounds, exerts a stimulating effect on the physiological condition of farm animals.

A synthesis of available literature addressing the important socio-economic challenge of increasing the productivity of livestock and poultry while producing organic animal products indicates that experimental data in this field remain insufficient in the contemporary scientific landscape. In particular, there is a need for in-depth investigation of the effects of the main components of *Poterium polygamum* on animal organisms, both when used individually and as part of phytomixtures. Therefore, the present study represents, in effect, an initial attempt to address this gap by incorporating *P. polygamum* into organic feed additives intended for the production of organic meat and dairy products.

CONCLUSIONS

Sowing *Poterium polygamum* into grass swards on drained peat soils proved to be ineffective and requires further improvement of cultivation technology.

On typical chernozem soils of the left-bank Forest-Steppe, *P. polygamum* demonstrated high technological suitability for organic fodder production. The crop is capable of maintaining stand cleanliness due to the allelopathic activity of its root system, which is of particular importance for crop management and energy saving.

Long-term studies revealed stable yields of *P. polygamum* over the years, with an average productivity of 11.7 $t \cdot ha^{-1}$ of green biomass, ranging from 9.4 to 15.5 $t \cdot ha^{-1}$, and 3.2 $t \cdot ha^{-1}$ of dry matter, varying between 2.3 and 4.6 $t \cdot ha^{-1}$. These yield levels are sufficient to justify its inclusion in organic feed additives.

The value of *P. polygamum* for organic fodder production is primarily associated with the presence of biologically active compounds, including flavonoids, tannins, saponins, and related constituents. In addition, the crop is characterized by high feed nutritional value and good palatability for animals, indicating its high potential for the formulation of phytomixtures for animal feeding.

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