Scientific Papers. Series A. Agronomy, Vol. LXVII, No. 1, 2024
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

BIOMASS QUALITY OF COMFREY, *Symphytum officinale,* AND ITS POTENTIAL APPLICATION IN THE REPUBLIC OF MOLDOVA

Victor ŢÎŢEI[1], Andreea ANDREOIU[2], Sergiu COŞMAN[3], Vasile BLAJ[2], Ana GUŢU[1], Teodor MARUȘCA[2], Valentina COŞMAN[3]

[1]"Alexandru Ciubotaru" National Botanical Garden (Institute) of Moldova State University, Chişinău, 18 Padurii Street, Republic of Moldova
[2]Research-Development Institute for Grassland, 5 Cucului Street, 500128, Brasov, Romania
[3]Scientific and Practical Institute of Biotechnologies in Zootechny and Veterinary Medicine, Maximovca, Republic of Moldova

Corresponding author email: vic.titei@gmail.com

Abstract

The quality of areal biomass of the local ecotype of common comfrey - Symphytum officinale - grown in the experimental plot of the National Botanical Garden (Institute), Chişinău, Republic of Moldova, was evaluated. The results revealed that the nutrient content of the Symphytum officinale whole plants harvested in the flowering period was characterized by the following indices: 186 g/kg CP, 129 g/kg ash, 217 g/kg CF, 278 g/kg ADF, 449 g/kg NDF, 35 g/kg ADL, 224 g/kg Cel, 171 g/kg HC and 160 g/kg TSS with 672 g/kg DDM, RFV = 139, 13.16 MJ/kg DE, 10.80 MJ/kg ME and 6.83 MJ/kg NEl. The prepared comfrey silage had pleasant smell and color, pH = 4.10, 38.2 g/kg lactic acid, 6.4 g/kg acetic acid and butyric acid were not detected. The silage dry matter nutrient content was 17.19% CP, 2.17% EE, 21.57% CF, 45.88% NFE, 1.82% starch, 0.86% soluble sugars, 13.18% ash, 0.89% Ca and 0.39% P. The biochemical methane potential of comfrey green mass substrate 362 l/kg.

Key words: *biochemical composition, biomethane potential, green mass, nutritive value, silage, Symphytum officinale.*

INTRODUCTION

The *Boraginaceae* Juss. family includes about 2213 species of shrubs, trees and herbs in 145 genera with a worldwide distribution, in the flora of Moldova, the family is represented by 24 genera, which include 57 species, which grow under the most diverse ecological conditions. It is one of the lesser known families of economic significance. The genus *Symphytum* L. of the *Boraginaceae* family includes 25-40 species, spread in the Mediterranean and moderately temperate region of Europe and Western Asia. There are 3 species in the flora of Bessarabia: *Symphytum officinale* L., *Symphytum tauricum* Willd., *Symphytum popovii* Dobrocz. (Ionița & Negru, 2021).

Common comfrey, *Symphytum officinale*, is a herbaceous perennial plant, native to Europe and Asia, growing 40-120 cm tall. The root system is a well-developed, thick taproot with many caudices, the rhizome is short and branched. The stem erect, winged-leafy, with stiff hairs, branched in the upper half. Leaves – simple, entire, hispid-hairy; the basal ones ovate-lanceolate, 15-30 cm long, acute, hispid-hairy, petiolate winged; the cauline leaves - lanceolate, sessile, decurrent. Inflorescence - apical cymes, drooping. Flowers bisexual, actinomorphic, pentamerous, pedicellate. Calyx gamosepalous, 10-15 mm long, deeply split; the lacinia of the calyx lanceolate, acuminate. Corolla pink or red-violet, tubular-funnel-shaped, 12-18 (20) mm long, with triangular, recurved lobes. Inside, there are 5 stamens, fused with the corolla tube. Bicarpellar gynoecium, filiform style, bilobed stigma. The fruits are ovoid nutlets, 4-5 mm long, trilobed, black, glossy, with an obvious caruncle at the base, at the base it is thickened in a ring-like shape. The plant reproduces by seeds. Also, new plants can be propagated by dividing the roots of established plants. *Symphytum officinale* is drought tolerant, also is very frost resistant. Common comfrey is a fast-growing plant. It prefers rich soils containing lime and grows best in moist, shady sites. It occurs mostly in humid lowlands, in the floodplains of rivers and lakes, in ditches and swales. It is used as honey, medicinal, forage and enegy biomass plant (Popescu et al., 1971; Medvedev & Smetannikova, 1981; Robinson, 1983; Bareeba et al., 1992; Denisow, 2008; Neagu et al., 2008; Hills, 2011; Thoresen, 2013; Martel, 2016; Ion et al., 2018; Oster et al., 2020; 2021; Ionița & Negru, 2021; Pandey et al., 2023).

The goal of this research was to evaluate the quality indices of areal biomass of the local ecotype of common comfrey, *Symphytum officinale*, as fodder for ruminant animals, as well as substrate for the production of biomethane.

MATERIALS AND METHODS

The common comfrey, *Symphytum officinale,* plants grown in the experimental plot of the National Botanical Garden (Institute) of MSU, Chişinău, N 46°58′25.7″ latitude and E 28°52′57.8″, served as subject of research and the traditional crop alfalfa, *Medicago sativa* and corn, *Zea mays*, were used as control variants. The common comfrey and alfalfa green mass samples were collected in the second growing season in the flowering stage. The leaf/stem ratio was determined by separating the leaves from the stem, weighing them separately and establishing the ratios for these quantities (leaves/stems). The dry matter content was detected by drying samples to constant weight at 105°C. For biochemical analysis, the plant samples were dried in a forced air oven at 60°C, milled in a beater mill equipped with a sieve with mesh diameter of 1 mm and some of the main biochemical parameters, such as crude protein (CP), ash, acid detergent fibre (ADF), neutral detergent fibre (NDF), acid detergent lignin (ADL), total soluble sugars (TSS), digestible dry matter (DDM) were determined by near infrared spectroscopy (NIRS) using PERTEN DA 7200. The concentration of hemicellulose (HC), cellulose (Cel), digestible energy (DE), metabolizable energy (ME), net energy for lactation (NEl) and relative feed value (RFV) were calculated according to standard procedures.

The common comfrey silage was prepared from plant harvested in the flowering stage, but the corn silage was prepared from plant harvested in the wax stage of grains. The harvested plants were chopped into 1.5-2.0 cm small pieces, with a laboratory forage chopper, compressed in well-sealed glass containers. The containers were stored for 45 days, and then, they were opened and the organoleptic assessment and the determination of silage pH index, concentration of organic acids (lactic, acetic and butyric) in free and fixed state, of the dry matter and its nutrient composition: crude protein (CP), crude cellulose (CF), crude fat (EE), nitrogen-free extract (NFE), soluble sugars (SS), starch, ash, calcium (Ca), phosphorus (P), were done in accordance with the Moldavian standard SM 108.

The carbon content of substrates was obtained using an empirical equation according to Badger et al. (1979). The biochemical methane potential was calculated according to the equations of Dandikas et al. (2015).

RESULTS AND DISCUSSIONS

As a result of the study on the agrobiological peculiarities of common comfrey, *Symphytum officinale*, we would like to mention that, in the second growing season, the plants come out of dormancy at the end of March, approximately at the same time as alfalfa. The growth and development of plants is faster at the end of April, the flowering stage starts 10-12 days earlier than alfalfa. At the flowering stage, *Symphytum officinale* plants reach 68-74 cm in height. The yield of common comfrey plants cut in flowering stage reached 4.42 kg/m^2 green mass or 0.78 kg/m^2 dry matter with 66.1 % leaves and flowers, but the traditional leguminous forage crop *Medicago sativa* at the first cut yielded 27.7 t/ha green mass, 7.2 t/ha dry matter with 52.9 % leaves and flowers. The biochemical composition, nutritive and energy value of the harvested green mass from common comfrey, *Symphytum officinale*, is presented in Table 1. We would like to mention that the dry matter of common comfrey plants contained 186 g/kg CP, 129 g/kg ash, 217g/kg CF, 278 g/kg ADF, 449 g/kg NDF, 35 g/kg ADL, 224 g/kg Cel, 171g/kg HC and 160 g/kg TSS with 672 g/kg DDM, RFV = 139, 13.16 MJ/kg DE, 10.80 MJ/kg ME and 6.83 MJ/kg NEl. The common comfrey green fodder, as compared with the traditional forage crop alfalfa, is characterized by a higher content of crude protein, minerals and total soluble sugars, lower content cell wall fractions, which has a positive effect on digestibility, relative feed value and energy concentration.

Literature sources indicate considerable variation in the chemical composition and nutritional value of *Symphytum* species fodder. According to Popescu et al. (1971) that dry matter of *Symphytum officinale* green herbage contained 28.7% CP, 17.5% ash, 3.1% EE, 16.0%CF, 34.8% NFE and 17.0 MJ/kg GE. Forbes et al. (1979) reported that proximate nutrient content of forage from *Symphytum* spp. was: 111-204 g/kg DM with 9.6-28.7% CP, 9.3-36.9% ash, 1.7-5.6% EE, 4.2-25.0% CF, 34.8-55.3% NFE, 14.1-18.0 MJ/kg GE and 7.6-10.2 MJ/kg ME. Medvedev & Smetannikova (1981) remarked that in *Symphytum asperum* the protein content varied from 13.6 to 21.8 %, and cellulose – from 13.5 to 23.2%, but in *Symphytum officinale* - the protein content varied between 14.3 and 21.9%, and cellulose - from 13.8 to 21.4%. Robinson (1983) mentioned that the quality of forage from comfrey cut five times per year was: 80-130 g/kg DM, 21-31% CP and 600-740 g/kg DDM. Bareeba et al. (1992) showed that *Symphytum officinale* green fodder was characterised by 128.9-149.6 g/kg DM with 14.55-16.95 % CP, 15.6-22.4 g/kg Ca, 4.3-5.1 g/kg P. Timofeev (2002) mentioned that the *Symphytum asperum* green forage contained 150 g/kg DM with 25.4 % CP, 15.7 % CF, 15.0% sugars and 11.2 MJ/kg ME. Wilkinson (2003) reported that herbage quality of *Symphytum officinale* harvested plants was 112 g/kg DM, 3.22% N, 10.7% WSC and 14.3% ash, but 24 h wilted materials, respectively 146 g/kg DM, 3.47% N, 11.8% WSC and 14.9% ash. Naranjo & Cuartas (2011) mentioned that the nutritional quality of forage from comfrey *Symphytum peregrinum* was 173 g/kg DM with 28.42% CP, 42.05% NDF and 39.28% ADF. Tran (2015) remarked that fodder value of Russian comfrey aerial part was: 124-150 g/kg DM, 14.6-29.3% CP, 2.5-5.4% EE, 9.4-14.0% CF, 18.8% NDF, 19.7-33.7% ash, 13.5-29.2 g/kg Ca, 3.4-10.0 g/kg P, 84.0% DOM, 15.3 MJ/kg GE, 12.2 MJ/kg DE and 9.8 MJ/kg ME. Ivanova & Elisovetcaia (2018) showed that *Symphytum officinale* green mass yield was 77.4-103.5 t/ha or 16.7-32.2 t/ha dry matter with 16.0-17.05% CP and 18.96% CF. Terranova (2018) found that *Symphytum officinale* forage contained 13.9-14.3% CP, 31.5-32.6% NDF, 29.8-30.5% ADF, 18.4% ash, 656 g/kg IVDOM. Tamakhina et al. (2019) found that the nutritional value in the budding-flowering stage of *Symphitum asperum* plants was: 98.4-107.5 g/kg DM with 11.30-15.90% CP, 2.86-3.00% EE, 14.22-14.53% CF, 51.51-58.10% NFE, 13.38-15.50% ash and 0.15 nutritive units/kg green mass, but of *Symphitum caucasicum* - 132.7-134.5 g/kg DM with 11.20-12.60% CP, 3.12-3.15% EE, 15.65-16.24% CF, 50.11-51.63% NFE, 17.40-17.90% ash and 0.16 nutritive units/kg green mass, respectively. Akhkubekova & Tamakhina (2020) remarked that *Symphytum asperum* forages contained 15.68-24.61% CP, 2.64-3.24% EE, 13.66-14.68% CF, 37.78-43.20% NFE, 4.14-5.80 g/kg P, but *Symphytum caucasicum* forages - 10.16-15.42% CP, 2.96-3.97% EE, 18.83-21.53% CF, 20.07-22.44% NFE, 1.63-2.65 g/kg P.

Table 1. The biochemical composition and the nutritive value of the harvested green mass from *Symphytum officinale*

Indices	*Symphytum officinale*	*Medicago sativa*
Crude protein, g/kg DM	186	170
Minerals, g/kg DM	129	90
Crude fibre, g/kg DM	217	341
Acid detergent fibre, g/kg DM ,	278	365
Neutral detergent fibre, g/kg DM	449	558
Acid detergent lignin, g/kg DM	35	63
Total soluble sugars, g/kg DM	160	63
Cellulose, g/kg DM	224	302
Hemicellulose, g/kg DM	171	193
Digestible dry matter, g/kg DM	672	605
Relative feed value	139	101
Digestible energy, MJ/ kg	13.16	11.96
Metabolizable energy, MJ/ kg	10.80	9.82
Net energy for lactation, MJ/ kg	6.83	5.83

Kotarev et al. (2018) reported that the dry matter and nutrient content in harvested *Symphytum asperum* green mass was 223.9 g/kg DM, 14.47% CP, 3.83% EE, 13.30% CF, 14.33% ash, 11.80% sugars with fodder value 2.86 MJ/kg ME and 0.29 nutritive units/kg green mass. Kamau et al. (2020) reported that the dry matter and nutrient content in the whole portion of *Symphytum* spp. was 149.6 g/kg DM, including 34.6 g/kg ash, 32.4 g/kg CP, 2.9 g/kg EE, 20.7 g/kg CF, 59.0 g/kg carbohydrate. Korelina & Batakova (2021) mentioned that the concentration of nutrients and the forage value of *Symphytum asperum* green mass was 156.93 g/kg CP, 102.03 g/kg DP, 260.87 g/kg CF, 31.58 g/kg sugars, 37.99 g/kg EE, 13.48 g/kg Ca, 3.00 g/kg P, with 0.73 nutritive units and 9.53 MJ/kg ME. Oster et al. (2021) remarked that the dry matter of comfrey leaves contained 32.5% CP, 18.6% ash, 2.7% EE, 12.6% CF, 10.8 g/kg Ca, 6.9 g/kg P and 64.9 g/kg K.

Silage making is one of several methods used for conserving animal feed, to improve the feed palatability and extend the storage time. The use of silage generally makes it possible to keep more animals on a given land area. We noted that the silage from *Symphytum officinale* plant had yellow-greenish stems, dark green leaves with brownish hues with pleasant smell specific to pickled fruits, but corn silage had homogeneous yellow colour with pleasant smell like pickled fruits; the consistency was preserved, in comparison with the initial plant green mass, without mould and mucus. The fermentation indices and nutrient content of the *Symphytum officinale* silage are illustrated in Table 2. It has been determined that common comfrey silage had pH index 4.10, higher as compared with corn silage. In terms of concentration of total organic acids, it did not differ essentially, but butyric acid was not detected and the concentration of fixed lactic acid was higher than in corn silage. Analysing the results of nutrient content we concluded that the dry matter of common comfrey silage contained a lower amount of crude protein and a higher amount of minerals as compared with the initial fresh mass. It was found that the level of crude protein, crude cellulose, minerals, calcium and phosphorus was very high in *Symphytum officinale* ensiled mass, but there was a reduced level of crude fats, nitrogen free extract and starch than in *Zea mays* silage. According to Wilkinson (2003) the comfrey silages contained 112-146 g/kg DM with 10.7-11.8% WSC, 3.22-3.47% N, pH=5.16-5.43.

Table 2. The fermentation profile, the nutrient composition of the silage prepared from *Symphytum officinale*

Indices	*Symphytum officinale*	*Zea mays*
pH index	4.10	3.73
Content of organic acids, g/kg DM	44.6	45.0
Free acetic acid, g/kg DM	2.9	3.6
Free butyric acid, g/kg DM	0	0
Free lactic acid, g/kg DM	10.1	16.7
Fixed acetic acid, g/kg DM	3.5	3.8
Fixed butyric acid, g/kg DM	0	0.2
Fixed lactic acid, g/kg DM	28.1	20.7
Total acetic acid, g/kg DM	6.4	7.4
Total butyric acid, g/kg DM	0	0.2
Total lactic acid, g/kg DM	38.2	37.4
Acetic acid, % of organic acids	14.35	16.44
Butyric acid, % of organic acids	0	0.44
Lactic acid, % of organic acids	85.65	83.12
Crude protein, % DM	17.19	6.83
Crude fats, % DM	2.17	3.50
Crude cellulose, % DM	21.57	16.47
Nitrogen free extract, % DM	45.88	69.69
Soluble sugars, % DM	0.86	0.79
Starch, % DM	1.82	24.82
Ash, % DM	13.18	3.52
Calcium, g/kg DM	8.9	2.3
Phosphorus, g/kg DM	3.9	2.5

Renewable energy offers numerous economic, environmental, and social advantages and it has become the core element of sustainable development nowadays. Biomass is a renewable source that can directly replace fossil fuels for present and future energy restriction, due to their environmentally friendly and renewable energy nature. Various processes can be used to convert biomass into energy, including biogas production. The use of biogas and biomethane as energy sources presents environmental benefits, ranging from decreasing greenhouse gas emissions to replacing fossil fuels and increasing efficiency in renewable energy production. The results regarding the quality indices and the biomethane potential of the common comfrey green mass substrate is shown in Table 3. Methanogenesis performed by methanogenic bacteria depends on the availability of essential elements for the methanogenic bacteria's metabolism, such as carbon (C) and nitrogen (N). The nitrogen content in the investigated *Symphytum officinale* green mass substrate was 29.76 g/kg and the estimated content of carbon 483.89 g/kg, the C/N = 16.26, but *Medicago sativa* green mass substrates contained 27.20 g/kg nitrogen, 500.0 g/kg carbon and C/N = 18.38. Essential differences were observed between the acid detergent lignin concentrations. The *Symphytum officinale* green mass substrate had lower content of cell wall fractions (449 g/kg), including acid detergent lignin (35 g/kg), which had a positive effect on the biochemical methane potential. Thus, the biochemical methane potential of comfrey green mass substrate reached 362 l/kg VS, compared to 314 l/kg of alfalfa green mass substrate. According to Xiaoman (2009) the potential of biogas production of comfrey substrate was 569.52 L/kg TS. Qiu et al. (2016) reported that the methane yield of *Symphytum officinale* substrate was 240 l/kg, but *Trifolium repens* substrate - 106 l/kg. Kamau et al. (2020) reported that the calculated biochemical methane potential of comfrey waste was 228.89 L/kg. Zhang et al. (2021) remarked that the methane yields obtained in experimental (batch and semi-continuous/continuous) tests in comfrey substrate were 323-334 l/kg VS, but alfalfa substrates - 220-330 l/kg VS.

Table 3. The biochemical biomethane production potential of the researched substrates

Indices	*Symphytum officinale*	*Medicago sativa*
Crude protein, g/kg DM	186.00	170.00
Minerals, g/kg DM	129.00	90.00
Nitrogen, g/kg DM	29.76	27.20
Carbon, g/kg DM	483.89	500.00
Ratio carbon/nitrogen	16.26	18.38
Hemicellulose, g/kg DM	171.00	193.00
Acid detergent lignin, g/kg DM	35.00	63.00
Biomethane potential, L/kg VS	362	314

CONCLUSIONS

The common comfrey, *Symphytum officinale*, plants are able to develop well under the climatic conditions of Moldova, and provide early-season, protein-rich fodder. The green mass and the prepared silage have optimal feeding value and, besides, the green mass may be used as substrate in biogas reactors for biomethane production as a source of renewable energy.

REFERENCES

Akhkubekova, A. A., Tamakhina A.Y. (2020). Reducing the risk of using the *Symphytum* genus varieties as forage for animals. *Izvestia Orenburg State Agrarian University,* 4 (84):91-96 [in Russian].

Badger, C.M., Bogue, M.J., Stewart, J. (1979). Biogas production from crops and organic wastes. *New Zeland Journal of Science*, 22:11-20.

Bareeba, F.B., Odwongo, W.O., Mugerwa, J.S. (1992). The potential of Russian comfrey (*Symphytum officinale*) as an animal feedstuff in Uganda. In: *The Complementarity of Feed Resources for Animal Production in Africa*. Addis Ababa, 249-255.

Dandikas, V., Heuwinkel, H., Lichti, F., Drewes, J.E., Koch K. (2015). Correlation between biogas yield and chemical composition of grassland plant species. *Energy Fuels*, 29 (11):7221-7229.

Denisow, B. (2008). Flowers ecology and pollen output of *Symphytum officinale* L. *Journal of Apicultural Science,* 52(2):81-89.

Forbes, J.C., Mckelvie, A., Saunders, P. (1979). Comfrey (*Symphytum* spp.) as a forage crop. *Herbage Abstracts*, 49 (2):523-539.

Hills, L.D. (2011). *Comfrey: Past, Present and Future.* Faber & Faber, 361 p.

Ioniţa, O., Negru, A. (2021). Genus *Symphytum* L. In. *Flora Basarabiei*, Vol.4, 396-399.

Ivanova, R., Elisovetcaia D. (2018). *Biological pesticides- plant for plant protection.* Nitra, 111p.

Ion, N., Odoux, J.-F., Vaissière, B. E. (2018). Melliferous potential of weedy herbaceous plants in the crop fields of Romania from 1949 to 2012. *Journal of Apicultural Science*, 62(2): 1-17.

Kamau, J.M, Mbui, D.N., Mwaniki, J.M., Mwaura, F.B. (2020). Lab scale biogas production from market wastes and dagoretti slaughterhouse waste in Kenya. *International Journal of Energy and Environmental Research*, 8(1):12-21

Korelina, V.A., Batakova, O.B. (2021). Prospects for the introduction of *Symphytum asperum* Lepech. into the Far North of the Russian Federation. *Proceedings on Applied Botany, Genetics and Breeding,* 182(1):41-47. [in Russian].

Kotarev, V.I.,Lyadova L.V.,Pronina E.V.,Goncharova T. S., Belousov D. A., Voloshina E.V. (2018). Prospects for the use of comfrey caucasian in the diet of chickens. *Bulletin of Veterinary Pharmacology,* 3 (4):77-81 [in Russian].

Martel, A. (2016). Transformation of *Symphytum officinale* L. and *Panicum virgatum* L. biomass to 5-hydroxymethylfurfural for biofuel production. Ontario, Canada. 136p.

Medvedev, P.F., Smetannikova, A.I. (1981). *The forage crops of European part of the USSR*. Leningrad, Kolos [in Russian].

Naranjo, J.F., Cuartas, C.A. (2011). Caracterización nutricional y de la cinética de degradación ruminal de algunos de los recursos forrajeros con potencial para la suplementación de rumiantes en el trópico alto de Colombia. *Revista CES Medicina Veterinaria y Zootecnia*, 6 (1): 9-19 [in Spanish].

Neagu, E., Moroeanu, V., Radu, G. (2008). Concentration of *Symphytum officinale* extracts with cytostatic activity by tangential flow ultrafiltration. *Romanian Biotechnological Letters,* 13:4008–4013.

Oster, M., Reyer, H., Keiler, J., Ball, E., Mulvenna, C., Muráni, E., Ponsuksili, S., Wimmers, K. (2020). Comfrey (*Symphytum* spp.) as an alternative field crop contributing to closed agricultural cycles in chicken feeding. *Science of the Total Environment*, 742 doi: 10.1016/j.scitotenv.2020.140490

Oster, M., Reyer, H., Keiler, J., Ball, E., Mulvenna, C., Ponsuksili, S., Wimmers, K. (2021). Comfrey (*Symphytum* spp.) as a feed supplement in pig nutrition contributes to regional resource cycles. *Science of the Total Environment*, 20:796:148988. doi: 10.1016/j.scitotenv.2021.148988.

Pandey, L.N., Shrestha, R., Shah, M., Baskota, N., Bhusal, K. (2023). Effects of comfrey grass (*Symphytum* spp.) included diets on the growth performance and carcass characteristics of turkey. *International Journal of Research Publication and Reviews*, 4(4):1442-1447.

Popescu, I.I., Pitis, S., Casanova, L. (1971). Studiul unor însusiri furajere la tătănească *Symphytum officinale* [Study of some fodder features of comfrey *Symphytum officinale]. Anale Universitatea Craiova. Biologie Stiinte Agricole,* 3:274-281.

Qiu, L., Wang, X.M., Qiu, Y.Q. et al. (2009). Experiment on anaerobic fermentation with lawn waste for eco-campus. *China Biogas,* 27(5):15-17 [In Chinese].

Robinson, R.G. (1983). *Comfrey - a controversial crop*. Minnesota Report Item No. AD-MR-2210 Agricultural Experiment Station University of Minnesota. https://conservancy.umn.edu/bitstream/handle/11299/141442/MR191.pdf

Tamakhina, A.Ya., Dzakhmisheva, I.Sh., Ahkubekova, A.A., Kantsalieva, Z.L. (2019). Assessment of the biological resource potential of species of *Symphytum* L. in the Flora of the Kabardino-Balkarian Republic. In. International scientific and practical conference *``AgroSMART - Smart solutions for agriculture'', KnE Life Sciences*, 1120-1128.

Terranova, M. (2018). *Potential of forages from temperate-climate woody and herbaceous plants to mitigate methane and ammonia in ruminants.* https://www.research-collection.ethz.ch/bitstream/handle/20.500.11850/321426/Dissertation_Terranova_2018.pdf?sequence=1&isAllowed=y

Thoresen, E.M. (2013). *Symphytum officinale.* Common Comfrey. Budapesta, 47p.

Timofeev, N.P. (2002). Protein value of new cultures in the conditions of the North. In. *Theoretical substantiation and practical realization,* 6:115-139 [in Russian].

Tran, G. (2015). Russian comfrey (*Symphytum* × *uplandicum*). *Feedipedia*, *https://www.feedipedia.org/node/92*

Wilkinson, J. (2003). A laboratory evaluation of comfrey (*Symphytum officinale* L.) as a forage crop for ensilage. *Animal Feed Science and Technology*, 104: 227-233. 10.1016/S0377-8401(02)00293-6.

Xiaoman, W. (2009). Potential of the biogas fermentation of comfrey. *Environmental Science* https://www.semanticscholar.org/paper/Potential-of-the-Biogas-Fermentation-of-Comfrey-Xiaoman/bcb8852456d0cadb81a0702572995fc0f4d996f2

Zhang, Y., Kusch-Brandt, S., Salter, A.M., Heaven, S. (2021). Estimating the methane potential of energy crops: an overview on types of data sources and their limitations. *Processes,* 9, 1565. https://doi.org/10.3390/pr9091565