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SOME BIOLOGICAL PECULIARITIES AND ECONOMIC VALUE OF THE CULTIVATION OF CUP PLANT, *SILPHIUM PERFOLIATUM* L.

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This article describes some peculiarities of the growth and development of the 'Vital' cultivar of *Silphium perfoliatum* L. and the advantages of its cultivation under the climatic conditions of the Republic of Moldova. It has been found that cup plant, in the second and the following years, has a growing season of 197-234 days, blooms and bears fruit, producing viable seeds. The flowering stage is long and staggered, thus, cup plant is a good source of pollen and nectar for bees and other insects. The aerial phytomass has high economic value as fodder for animals and as substrate for the production of renewable energy.

Keywords: *renewable energy, biological peculiarities, Silphium perfoliatum cv. 'Vital', fodder value.*

UNELE PARTICULARITĂȚI BIOLOGICE ALE SPECIEI *SILPHIUM PERFOLIATUM* L. ȘI VALOAREA EI CULTURALĂ

În lucrare sunt descrise unele aspecte ale creșterii și dezvoltării speciei *Silphium perfoliatum* L., soiul 'Vital', fiind specificată valoarea economică a acesteia în condițiile climatice ale Republicii Moldova. S-a stabilit că în anul doi și în următorii ani de creștere plantele de silfie au o perioadă de vegetație de 197-234 zile, înfloresc și fructifică, formând semințe viabile. Perioada de înflorire este îndelungată**,** eșalonată, asigurând o sursă de polen și nectar pentru albine și alte insecte. Fitomasa aeriană are valoare economică ca furaj pentru animale și ca substrat pentru obținerea energiei renovabile.

Cuvinte-cheie: *energie renovabilă, particularități biologice, Silphium perfoliatum, soi 'Vital', valoare furajeră.*

Introduction

Silphium is a genus of 17 species in the tribe *Heliantheae*, family *Asteraceae*. All these species are native to North America. Among them, by now, only *Silphium perfoliatum, Silphium laciniatum, Silphium terebinthinaceum* and *Silphium integrifolium* have been of economic interest. In Europe, *Silphium perfoliatum* was introduced in the 18th century, and was initially used as ornamental plant in gardens and parks in Germany, France, Switzerland and the United Kingdom. It is a perennial plant which grows up to 2.0-3.5 m tall, tolerates various soil and climatic factors and produces high yields of biomass rich in amino acids, proteins, nitrogen free extract and minerals. The leaves, inflorescence and rhizomes of the cup plant are rich in phenolic acids, such as caffeic, p-Coumaric, ferulic, protocatechuic, p-hydroxybenzoic, vanillic and chlorogenic acid, both in free and bound form. *Silphium perfoliatum* is currently subject of scientific investigations in several universities and scientific centres around the world. The increased interest in this species is associated with its potential as honey, fodder, medicinal, technical and energy crop [1-8]. In the Republic of Moldova, this species was introduced in the collections of the Botanical Garden in the second half of the twentieth century, then, over the years, valuable forms were identified and, as a result of breeding, the 'Vital' cultivar was created, registered in the Catalogue of Plant Varieties in 2012 and patented at the State Agency for Intellectual Property (AGEPI) in 2016 [9-10].

Materials and Methods

The plants of the 'Vital' cultivar of *Siphium perfoliatum* L. grown in the experimental plot of the Plant Resources Laboratory served as research subjects. The study on the growth and development characteristics was carried out according to the approved methodological indications [11]. The fresh mass samples for evaluation were taken in August, cut into pieces and subjected to dehydration in an oven with forced ventilation at a temperature of 60°C; after fixing the biological material, it was finely ground in the laboratory ball mill. The evaluation of the content of crude protein (CP), crude ash (CA), neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL) and the determination of the digestible dry matter (DDM) and digestible organic matter (DOM) by applying the method of near-infrared spectroscopy (NIRS) by PERTEN DA 7200 technical equipment from the Research-Development Institute for Grasslands in Brasov, Romania, were done by using standard methods. The content of cellulose (Cel), hemicellulose (HC), relative feed value

(RFV), digestible energy (DE), metabolizable energy (ME), net energy for lactation (NEl) were estimated according to accepted equations. The specific methane yield (Ym) was evaluated based on the content of the chemical compounds of the cell walls – acid detergent lignin (ADL) and hemicellulose (HC) of the substrate, according to the equations: Ym=371+0.13HC-2.0 ADL [12]. The dry biomass was harvested manually, chopped into chaff using the stationary forage chopping unit, milled in a beater mill equipped with a sieve with a diameter of openings of 6 mm. The automatic calorimeter LAGET MS-10A with accessories was used for the determination of the calorific value, according to CEN/TS 1540, the briquettes and pellets were prepared by using the equipment developed at the Institute of Agricultural Technique "Mecagro" Chisinău, the mean compressed (specific) density of the briquettes and pellets was determined immediately after removal from the mould as a ratio of measured mass over calculated volume.

Results and Discussions

Under the climatic conditions of the Republic of Moldova, the cup plant, *Silphium perfoliatum*, in the first year of life, formed only a rosette of 15-20 cordate, triangular leaves with finely to coarsely toothed margins and sharply pointed tips. Starting from the second year, it grew, developed and produced fruits every year. The growing season of the cup plant began at the end of March. The rosette formed during 25-35 days, depending on the weather conditions (Fig.1B). Then, the formation of the stems started; a plant developed 5-19 generative stems, stout, glabrous and 4-angled, at the end of May reaching 186-213 cm in height. The leaves at the base of the stem are petiolate, opposite, and in the upper part of the shoot each leaf base is wide and fused around the stem, forming a cup, which the stem seems to pierce; during the night and in the morning, a considerable amount of water accumulates in it and thus the plant is more efficiently adapted to harsh environmental conditions. In June, the formation of floral buds began (Fig.1C). Firstly, 2-3 buds were formed at the top of the generative shoot, in the next 6-8 days another 3-6 buds appeared, so, up to 60 floral buds developed on a shoot.

The first flowers were observed at the end of June (Fig.1D). The flowering stage was long and staggered; on the shoots, there were simultaneously flower buds, flowers and seeds. In mid-July, seed formation began. *Silphium perfoliatum* has yellow, sunflower-like composite flowers, which are grouped in compound inflorescences – dichasia, consisting of layered branches, with 50-60 yellow flower heads of 4-6 cm in diameter. During the flowering stage, the plantation was visited by pollinating insects, including honeybees that collected pollen and nectar (Fig.2). The fruit is a brown achene with a marginal wing used for wind dispersal. About 20-30 achenes with a length of 8-14 mm were produced in each flower head (Fig.1A). The weight of 1000 achenes was 18-25 g. The growing season ended in autumn, when temperatures dropped below 0°C.

A **B** **C** **D**

Figure 1. A – seeds; B – the development of the rosette of leaves; C – budding; D – flowering.

As mentioned in the literature, under the climatic conditions of Poland, the cup plant bloomed between June 28 and September 10, developed 74-83 thousand flowers per m^2, the sugar content in nectar reached 36-61 %, and the potential for obtaining honey was 418-777 kg/ha [5]. It was found that the plants of the 'Vital'

cultivar of the cup plant, at the end of the flowering stage, reached 320-373 cm in height, and the yield of aerial phytomass was 12-15 kg/m^2. The dry matter from the harvested phytomass contained 66 g/kg crude protein, 46 g/kg ash, 604 g/kg NDF, 411 g/kg ADF, 83 g/kg ADL, 328 g/kg cellulose, 193 g/kg hemicellulose, 569 g/kg digestible dry matter, relative feed value (RFV) = 92, 11.32 MJ/kg digestible energy, 9.2 MJ/kg metabolisable energy and 5.31 MJ/kg net energy for lactation.

Figure 2. Pollinating insect (honeybee).

Silphium perfoliatum is considered a potential energy crop, since the harvested fresh aerial phytomass can serve as substrate for anaerobic digestion at biogas plants. It was estimated that the phytomass substrate from the 'Vital' cultivar of the cup plant, harvested at the end of the flowering stage, had a biomethane production capacity of 230 l/kg and the potential productivity of a plantation was 6500-7000 m^3 biomethane per hectare. Siwek et al., 2019, mentioned a biomethane production potential of the *S. perfoliatum* substrate of 8598 m^3/ha, as compared with 4759 m^3/ha for *Sida hermaphrodita* L. Rusby [13].

Figure 3. Energy biomass, briquettes and pellets.

It was determined that the moisture content of *Siphium perfoliatum* biomass harvested in March was 14% and milled chaff biomass – 11.6%, the bulk density of the milled chaffs – 233 kg/m^3, the ash content – 3.0 %, the net calorific value – 16.7 MJ/kg, the bulk density of pellets – 656 kg/m^3, the specific density of briquettes – 949 kg/m^3 and pellets – 1038 kg/m^3 (Fig. 3). According to Frączek et al. [14], the cup plant biomass has specific density – 210 kg/m^3, heat of combustion 17.3 MJ/kg and ash content – 3.4%, the specific density of briquettes – 920 kg/m^3 and durability – 93.1%.

Conclusions

The climatic conditions of the Republic of Moldova are suitable for the normal growth and development of *Siphium perfoliatum* plants, which are able to complete the entire development cycle, ending the growing season with the production of viable seeds. The 'Vital' cultivar of *Siphium perfoliatum* is characterized by long and staggered budding and flowering, producing many flowers which attract bees and other pollinating insects. The aerial phytomass harvested at the end of the flowering stage can serve as high quality forage for livestock, but also as substrate for biogas plants and as fertilizer for organic farming; the dry biomass harvested in March - for the production of briquettes and pellets for renewable energy.

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