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PROTEIN CONTENT VARIATION IN GRASS OF SPONTANEOUS VETCH AND SWEET PEA SPECIES

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Abstract

Legumes, as a source of proteins and energy, are one of the major plants used for food and forage since olden times. Range of *Lathyrus* (sweet peas) and *Vicia* (vetches) species grow in natural meadows of Lithuania. Due to their current economic value and potential for future utilization, *Vicia* and *Lathyrus* genus had a high priority for organic ruminant farm forage development.

The grass protein content, studies of spontaneous perennial *Vicia* and *Lathyrus* species were carried out. Fife *Vicia* genus (*V. cracca*, *V. sepium*, *V. villosa*, *V. amngustifolia*, *V. hirsuta*) and three species of the *Lathyrus* genus species (*L. pratensis*, *L. sylvestris*, *L. palustris*,) were studied in collection of university Experimental station of Lithuanian University of Agriculture, Middle Lithuania, on soil – clay loam on sandy light loam *Calc(ar)i-Endohypogleyic Luvisol(LVg-n-w-cc*). The evaluation of grass protein content was based on testing of the individual plant grass mass ant parts like foliage, stems and flowers. The crude protein analysis was carried out using the Kjeldahl method.

The protein content in dry matter of grass varied between species and investigated plant parts. The lowest volume of protein was in stems of investigated species and the highest one – in blossoms. The protein content of the blossoms of the tested species ranged from 32.1 % up to 40.5 %, the protein content in foliage ranged from 21.4 % to 29.6 %. The largest portion in the tested species grass mass consisted of leaves (on average 50.8 %). The total foliage protein content of the tested vetch species was on average 25.62 %, and a little less in the sweet pea species – on average 23.13 %. *V. sepium* and *L. sylvestris* were characterized by the highest protein content in the grass. *L. pratensis* and *V. cracca* were described by the lowest volume of protein. The relationship between the tested parameters and the location of geographical origin was not found during the experimental period.

Keywords: *Lathyrus*, *Vicia*, grass, protein content.
JEL Codes: Q01, Q10, Q57.

Introduction

Some 50 000 well-grazed spontaneous plant species grow around the world. Only negligible portion has been tamed (Loftas, 1995). Since olden times the plants of *Fabaceae* family, as a source of energy and protein, are one of the major plants used for food and forage. Nutritionally, the leguminous plants are on the second place after the representatives of the *Poaceae* family. Legumes are valued for their ability to fix biological nitrogen and protect the soil from erosion. They are also used for phytomelioration and as living mulches for alternative cropping systems (Sheaffer, Seguin, 2003, Baresel et al., 2002).

Worldwide, Fabaceae (*Leguminosae*) with 800 genera and 20 000 species, is the third largest family of flowering plants, after the *Orchidaceae* and *Asteraceae* (Lewis et al., 2005). *Vicia* subgenus *Vicia* contains several economically important food and forage legume species which have a centre of distribution in the Eastern Mediterranean (Maxted, 1995; Smykal et al., 2015). *Lathyrus* genus is considered to be young and progressive one (Attokurov, 1993). Due to their current economic value and potential for future utilization, *Vicia* was ascribed a high priority by the International Board for Plant Genetic Resources (IBPGR) forage working group for collection, conservation and forage development (Maxted, 1995).

160 species of only *Vicia* plants are used for food and fodder. Only small part of these species have been domesticated. Extinction of species and populations promotes search for and selection of valuable spontaneous species. The species under investigation are assessed not only as forage (Sheaffer and Sequin, 2003) but also according to their ability to adapt to changing climatic conditions, genetic stability of major quality parameters, disease and pest resistance. The noticeable decline in the species and population induces the expanded search and selection of valuable spontaneous species (Ckvorcov, Kuklina, 2002).

The chief object of domestication is not the species as a whole, but its individual ecotypes. The priority work is an investigation of species biodiversity and selection of promising ecotypes.

In Lithuania, there grows 39 tribes of the *Fabaceae* family, some 115 species, among which the spontaneous species make 13 species of *Vicia* (vetches) and 9 species of *Lathyrus* genus (sweet peas) (Natkevičaitė-Ivanauskienė, 1983). Perennial, long-living (20 years and more) species of *Fabaceae* family *Vicia* (*V. cracca*, *V. sepium*) and *Lathyrus* (*L. pratensis*, *L. palustris*, *L. sylvestris*) genera that are of good fodder value grow in natural meadow of Lithuania (Stancevičius, 1971, Sliesaravičius, Petraitytė, 2001).

Since 1996, Lithuania has been implementing the program named The Lithuanian Research and Conservation Program of Genetic Resources of Plants and Agricultural Animals (Gene Pool), later – the Scientific Research Program of Plant Genetic Resources, according to which since 1998 the genetic resource researches of the economically valuable species *Vicia* and *Lathyrus* have been performed under equal

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agrotechnic conditions (*ex situ*) in the Lithuanian University of Agriculture (now – Aleksandras Stulginskis University).

Under the research programme "Genofund" collection of *in situ* growing *V. cracca*, *V. sepium*, *L. pratensis*, *L. palustris* and *L. sylvestris* coenopopulations has been accumulated at the ASU since 1998. At the same time coenopopulations of short - lived *V. villosa*, *V. angustifolia* and *V. hirsuta* that are of high fodder value and characteristic to agrophytocoenoses have been collected.

Annual species:

***V. angustifolia* L. (**narrow-leaved vetch**)** is a pioneer of the genus (Sinskaya, 1969), another Latin name – *V. sativa* ssp. *nigra* L. (L.) (Maxted, 1995). A range of intermediate forms between *V. angustifolia* and *V. sativa* (Sinskaya, 1969) was identified. The phylogenetic relationships test between individual *Fabaceae* species revealed *V. angustifolia* to possess one of the highest genetic polymorphism levels (Nickrent and Patrick, 1998), which partly confirm the theory of origin of species of *Vicia* genus. *V. angustifolia* belongs to the elements of the west-Asian flora and grows almost in all Europe, America, Australia and South Africa. Narrow-leaved vetch is an annual plant, terophyte and rarely overwinters (Stancevičius, 1971). In Lithuania *V. angustifolia* is rather common and grows on various soils, in cereal crops as a weed, dry grasslands, forests and bush (Sliesaravičius et al, 2005; Maršalkienė[1], 2015). The accessions of *V. angustifolia* – narrow-leaved and *V. hirsuta* – hairy vetch, both collected during expeditions, often grew together in spring cereal phytocenoses, less often – in winter cereal phytocenoses, waste or abandoned land, less frequently – in grasslands, sandy loam and light loam soils (pH 5.8–7.0). These species are rather frequent on the whole territory of Lithuania, especially in the south and southeast regions of the country, which are characterised by sandy soils, and less frequent – in northern Lithuania (Sliesaravičius et al., 2005; Maršalkienė[1], 2015).

V. villosa (winter or hairy vetch) is thought to have originated on the Mediterranean littoral. It belongs to the European flora element (Stancevičius, 1971). is a legume primarily used for forage, hay, silage and green manure (Wiesermana, Leon, 2013; Renzi et al. 2017). *V. villosa* provides a good soil cover and is used as to control weeds in alternative cropping systems (Anugroho et al., 2009; Mischler et al., 2010; Halde et al. 2015) and as a soil amendment (Cook, 2010; Viesermana and Leon, 2013; Cicek et al, 2014). Hairy vetch is well adapted to organic cultivation and grows well on a wide range of soil types – on sandy, nitrogen depleted and light acidity soils (Sheafer and Seguin, 2003; Dastikaitė et al, 2009). In this sense *V. villosa* is of interest to agricultural science and practice ant is partly domesticated. In Lithuania, hairy vetch (as is the wild type) is a rather rare plant and mostly grows in agrocoenoses as a weed (Maršalkienė, 2015[1]). *V. villosa* was specific to rye agrophytocenoses, it occurred less frequently on waste or abandoned land and seldom in spring cereals and potatoes. Winter vetch grows on different acidity (pH 5.1–6.9) sandy loams, in some sites even on sandy soils. *V. villosa* is the most widespread plant in the south-east and east of Lithuania, far less frequent – in south-west and center of Lithuania, it was not found at all in northern Lithuania. Only one accession of this plant was found in the north-western part of the country (Maršalkienė[1], 2015; Maršalkienė[2], 2015).

V. hirsuta (tiny vetch) is native to europe and introduced to various other parts of the world, including North America. V*icia hirsuta* is found in grassland, scrub, forest margins and lava plains at 2000–3500 m altitude. *Vicia hirsuta* is a long-day plant. In many countries it is considered a weed (Brink, 2006). The seeds of *Vicia hirsuta* are collected from the wild and eaten cooked or roasted in Ethiopia. They were eaten as a famine food in Europe and Asia. The leaves and shoots are used as a vegetable in Ethiopia. *Vicia hirsuta* is also a forage (Thulin, 1983).

Perrenial species:

V. cracca (cow vetch, tufted vetch) is native in Europe, Asia and adventive in North America. It often occurs in meadows, fields, pastures, gardens and kitchen-gardens, sometimes it grows on fields with grain crops (Stancevičius, 1971). *V. cracca* can grow on different kinds of soil, from alkaline to acidic peat and may be used to curb erosion. Cow vetch is widely used as a forage crop for cattle and is well eaten by other animals also (Egorova,1978). Cow vetch is also attractive to bees and butterflies as a source of nectar (Afonin et al, 2008; Egorova,1978). V. *cracca* is one of the most common and wide spreed *Vicia* genus plants and meadow species in Lihuania.

V. sepium (bush vetch) is widely distributed in Europe and North Asia, introduced from the Old World to North America. *V. Sepium,* same as *V. sativa*, is a pan-temperate species, which greatly extends its distribution area (Maxted, 1995). *V. sepium* is regarded as a primitive member of subgenus *Vicia*, because of its perennial habit, a relatively long peduncle and numerous flowers per peduncle (Maxted, 1995). *V. sepium* is a perrennial hemicriptophyte, common on roadsides, meadows, pastures, hedgerows (Stancevičius, 1971; Afonin et al, 2008). According to the number of proteins *V. sepium* occupies one of the first places among leguminous grasses (Sliesaravičius, 2001; Medvediev, 1956). The plant vegetates early, it is resistant to winter kill, preferred by animals, remains in herbage for a long time, is suitable as a constituent part of perennial meadow composites (Medvedev, 1956; Larin, 1951). Characterized by high seed productivity in unfavorable years. High nutritive value. Can by utilized for hay or silage, particularly arable silage, from perennial grasses/vetch mixtures (Afonin et al, 2008). In the second part of the 19th century *V. sepium* attempts to sow in Russia, and in the 20th century it was sown in various regions of the former Soviet Union's European part and Western Siberia, yet the species

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was not cultivated (Medvedev, 1956). The research carried out at the Institute of Botany in 1978–1980 revealed that *V. sepium* is one of the most perspective species of leguminous green fodder in Lithuania (Vitkus, 1998). One-and two-time flowering cenopopulations were found, and early and late flowering forms of the bush vetch were distinguished in Lithuania (Maršalkienė, 2016).

L. pratensis **(**meadow vetchling) is native to Europe and Asia, has been introduced to other parts of the world, is a native perennial of moderately fertile soils found in a range of grasslands including meadows, hedges, banks and unimproved and lightly grazed pastures (Stancevičius 1971, Gulenkova, Egorova,1978). This plant has been propagated in the past as animal fodder (Afonin et al, 2008) and well eaten by horses, sheep and dear, not so well by cattle and recommended in mixture with othe grasses. Meadow vetchling is more dependent upon rhizomal spread than seed drop to regenerate and so is able to persist within pasture and meadows where plants are cut back before seed pods have ripened. Seed, which can survive ingestion by cattle, is important for the colonisation of new sites. In Lithuana is rather common species in natural and semi-natural meadows (Gulenkova, Egorova,1978).

L. sylvestris (flat pea**) is** native to Europe, parts of Africa and Asia. Flat pea is adapted to a wide range of soils and tolerant of numerous environmental factors that restrict the growth of many other plant species (Stancevičius, 1971; Shen, Foster, Orcutt, 1990). Flat pea is a long-lived erosion control plant that can grow on severely disturbed soil under acid conditions and begin a soil improvement process as well used as living mulch (Shen, Foster, Orcutt, 1990). Flat pea possesses numerous characteristics that make it a potentially valuable agricultural species. *L. sylvestris* is not very common in Lithuania and use to grow in forest edges, dry hillside meadows, embankments and waste ground and, like pioneer species, on highway slopes.

L. palustris (marsh pea) is native to Europe, Asia, and North America. It prefers full sun and moist or wet soils: grows on meadows beside rivers, lakes and the sea (Stancevičius, 1971; Afonin et al, 2008). It is of great importance in crude places since it grows well under conditions of excessive humidity (Afonin et al, 2008). Seeds are edible, no records of toxicity have been found for this plant, the seed of some *Lathyrus* species in this genus contain a toxic amino acid that can cause a severe disease of the nervous system known as 'lathyrism' if they are eaten in large amounts (Archis 2015). *L. palustris* in Lithuania is rare plant. The succession of communities, caused by drainage, or transfer exploitation of wet meadows to extensive one, rise of water level by beavers activities have extruded *L. palustris* in Lithuania.

The objective of work: to assess the above-ground mass productivity and protein content (crude protein) n the total grass of the economically valuable self-seeding species of vetches and peas.

Materials and methods

Plant mass productivity studies were carried out in 2004-2008, using the collection of the Experimental three species of the genus *Lathyrus* were studied: *V. angustifolia* (narrow-leaved vetch) – 15 ecotypes; *V. hirsuta Grey* (hairy vetch) – 15; *V. villosa L.* (winter vetch) – 56; *V. cracca L.* (tufted vetch) – 52; *V. sepium* (bush vetch) – 14; *L. pratensis L.* (meadow pea*) – 45*; *L. sylvestris L.* (flat pea) – 12, *L. palustris L.* (marsh pea) – 3 ecotypes.

The seed specimens of the studied species were collected from different geographical origins of Lithuania in 1998-2001. The annual vetches (*V. angustifolia* and *V. hirsuta*) were sown in spring, on the third-fourth decade of April; *V. villosa* – on the first decade of September. The species of annual vetches were grown in a particular agrophytocenosis of the crops, characteristic to these species (*V. angustifolia* and *V. hirsuta* - with barley; and *V. villosa* – with rye); the species of perennial vetches (*V. cracca*, *V. sepium*) and sweet peas (*L. pratensis, L. sylvestris and L. palustris*) were sown on the 5th of May in 2003, using the field boxes of two square meters in size, together with the wild perennial grasses, particular for phytocenosis plants (*Phleum pratense* L.; *Lolium perenne* L.; *Festuca pratensis* Huds.).

The assessment of above-ground mass weight and protein content was based on determination of the average above-ground mass weight of one plant, its ratio of leaves, blossoms and inflorescences in the total mass, as well as the crude protein content of the individual plant ground mass parts (leaves, stems, flowers) and the protein content of the total ground mass. During the study, 10 plants at their early buttonisation-flowering stage were taken from each field box for this research. The morphometric analysis of specimens was performed in the laboratories of the Department of Plant Production of the Lithuanian University of Agriculture. The crude protein analysis was carried out in the Centre of Agrochemical Researches of the Lithuanian Institute of Agriculture (now – branch of the Lithuanian Research Centre for Agriculture and Forestry, Laboratory of Agrochemical Researches), using the Kjeldahl method. The researches were carried out during 2004-2008.

Results

Among the tested species, the maximum stem height and the greatest above-ground mass was observed in the species of *L. sylvestris* L. and *V. villosa* (Figure 1). The vetches of *V. angustifolia* and *V. sepium* had the shortest stems. The above-ground mass weight of the plants of the tested species correlated with the stem height.

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It was determined the positive linear relationship between stem height and above-ground mass weight (r = 0.880). However, the above-ground mass was also dependent on the morphometric traits of the tested species: size of the leaves and blossoms, their branchiness. The lowest above-ground mass was observed in the vetches of the *V. hirsuta*, whose stem height was one of the highest ones, if compared with other species.

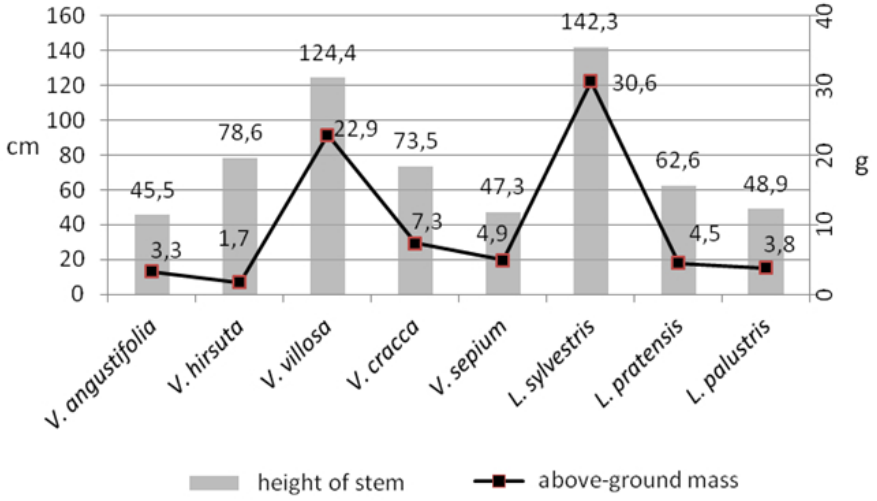

Figure 1. Stem height and above-ground mass weight of vetches and sweet peas
(*Experimental Station of the Lithuanian University of Agriculture (LUA), 2004-2008*)

The largest portion in the above-ground mass of the tested species (excluding *V. villosa*) consisted of foliage –average 52.4 % (Figure 3.12). The leaf mass of different species ranged from 42.1 % to 56.0%. The largest foliage mass was observed in the plants of the species of *L. pratensis*, *V. cracca* and *V. angustifolia*. The stem mass of all species tested was smaller than the foliage mass, and ranged from 41.5 to 45.7 %, an average value was 43.7 %. The mass of inflorescences in the above-ground mass ranged from 2.3 to 2.5 %, because during the research years the plants of the species *V. villosa* used to have averagely 14.5 % blossoms of the general above-ground mass, it means 5.8–6.3 times more than other tested species of vetches and sweet peas (Figure 2).

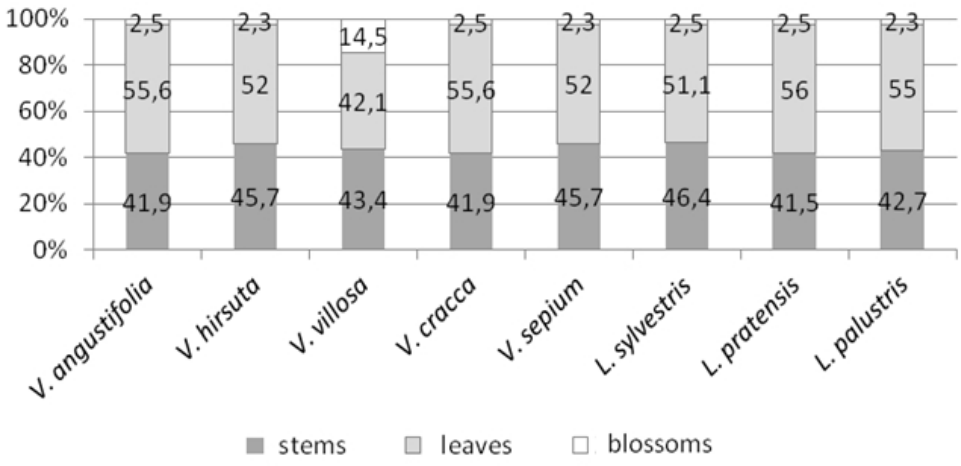

Figure 2. Ratio of the stems, leaves and blossoms in the total plant mass
(*Experimental Station of the Lithuanian University of Agriculture (LUA), 2004-2008*)

The highest protein content in the above-ground mass consisted of blossoms (Figure 3). The protein content of the blossoms of the tested species ranged from 33.1 % (*V. angustifolia*) up to 40.1 % (*V. sepium*), and it reached 33.4 % on average. The protein content of blossoms of *V. sepium* was especially high – 6.7 % higher than the general average of the species tested. The crude protein content in foliage ranged from 21.4 % (*L. pratensis*) to 26.9 % (*V. villosa*). The total foliage protein content of the tested vetch species was on average 25.62 %, and a little less in the sweet pea species – on average 22.13 % (Figure 3.13). The average volume of crude protein of the stems of the studied species was 9.8 %. The highest volume of crude protein of the stems (on

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average 13.3 %) was observed in the annual vetches (*V. hirsuta*, *V. angustifolia* and *V. villosa*). *V. villosa* (21.9 %), *L. sepium* (21.9 %) and *V. angustifolia* (20.3 %) were characterized by the highest volume of crude protein in the above-ground grass mass. *L. pratensis* and *V. cracca* were described by the lowest volume of crude protein.

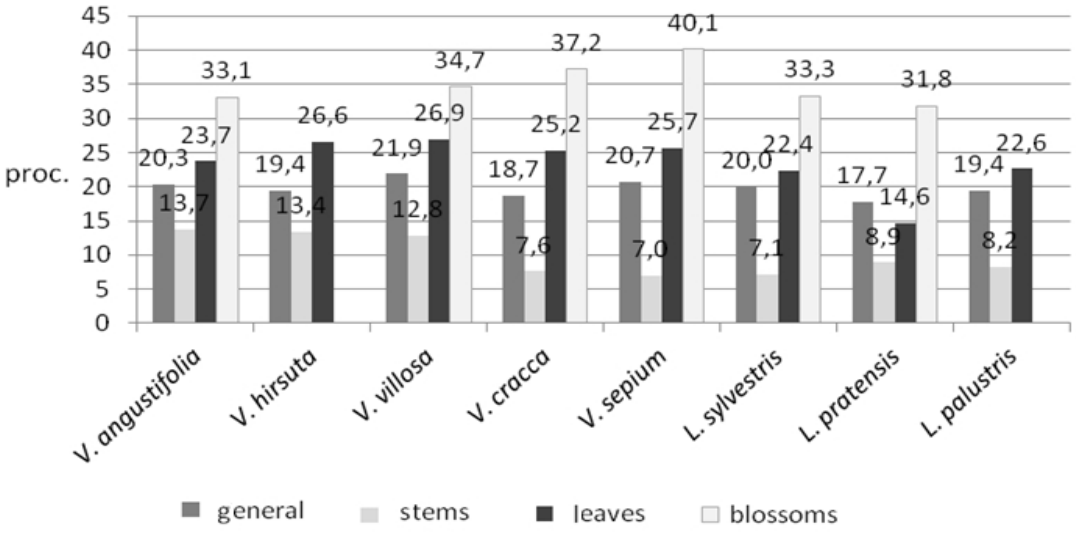

Figure 3. The protein content of vetches and sweet peas in the above-ground mass
(*Experimental Station of the Lithuanian University of Agriculture (LUA), 2004-2008*)

Conclusions

1. The greatest values of stem height and ground mass were observed in the species of *L. sylvestris* and *V. villosa* among the tested species.
2. The largest portion of the ground mass of the tested species consisted of leaves, the smallest – of inflorescences. The largest relative leaf proportion was observed in the species of *V. cracca* and *V. angustifolia*, and the largest relative inflorescence proportion – in the grass of the species of *V. villosa*.
3. Among the different plant parts of all the tested species, the greatest protein content was observed in inflorescences. The highest protein content was determined in the *V. sepium* inflorescences. The highest protein content was determined in stems of the annual vetches (*V. hirsuta*, *V. angustifolia* and *V. villosa*).
4. *V. villosa* (21.9%), *L. sepium* (21.9%) and *V. angustifolia* (20.3%) were characterized by the highest crude protein content in the above-ground mass, while *L. pratensis* and *V. cracca* – by the lowest.

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