

Morphological features and productive potential of plants of the genus *Vigna* Savi. in the conditions of the Right-Bank Forest-Steppe of Ukraine

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Aim. To conduct a comprehensive study of morphological features of the genus *Vigna* plants, to assess their productive potential depending on the species characteristics under the conditions of introduction in the Right-Bank Forest-Steppe of Ukraine. **Methods.** The main method of work was a comparative morphological analysis of plants grown from seeds. The research was carried out at the introduction sites and in the laboratory of the Department of Cultural Flora of the M. M. Gryshko National Botanical Garden of the National Academy of Sciences of Ukraine during 2019–2021. Plants of four species of the genus *Vigna*: *V. radiata* (L.) R.Wilczek, *V. angularis* (Willd.) Ohwi & H. Ohashi, *V. mungo* (L.) Hepper, *V. unguiculata* (L.) Walp were the material for the study. We studied the patterns of growth processes and plant development depending on species characteristics. Soil germination of seeds without prior preparation was determined depending on species characteristics. Field, laboratory and methods of analysis of variance and statistical evaluation of average data using Microsoft Excel (2010) were used. **Results.** It was revealed that the seeds of plants *V. radiata*, *V. angularis*, *V. mungo*, *V. unguiculata* being introduced in the Right Bank Forest-Steppe of Ukraine were characterized by a high level of sprouting energy (from 64.8% in *V. angularis* to 78.9% in *V. unguiculata*) and germination (from 84.3% in *V. radiata* to 99.6% in *V. angularis*), the intensity of growth and development of *aboveground and underground organs* during the growing season and seed productivity (from 468 g/m² in *V. radiata* to 585 g/m² in *V. mungo*). This indicates the prospects of their cultivation as a source material for breeding research and the advisability of use in crop production, which will expand the potential of the raw material base in addition to traditional legumes and cereals. **Conclusions.** The morphological characteristics of seeds, vegetative and reproductive organs of plants of the genus *Vigna* were studied. Peculiarities of formation of seed productivity, aboveground and underground part of plants during vegetation depending on species specificity in the conditions of introduction in the Right-Bank Forest-Steppe of Ukraine were determined.

Keywords: species of the genus *Vigna*; introduction; productivity; morphological features.

Introduction

According to the UN, in recent decades there has been a rapid increase in the population on the planet [1], so the demographic issue today is perhaps the most relevant among the scientific community, including the natural sciences [2]. In particular, in the middle of the twentieth century (as of 1950) the total population was

2.5 billion, and at the end (1999) – 6 billion [3]. Currently, in 2022, according to the Worldometer resource [4], it reaches about 8 billion. Such a demographic boom raises a number of scientific issues that require an immediate solution, the leading place among which is ensuring the food security of mankind [5, 6].

Protein food is the basis of any living organism, including the human one [7]. Plants, in particular representatives of the *Fabaceae* family, are among the prevailing sources of relatively cheap and useful protein [8–10].

Soybean [*Glycine hispida* (Moench) Max], which is called the crop of the 21st century, is the main leguminous crop on the world market of agricultural products today [11]. It has powerfully entered the world agricultural production, plays a strategic role in solving the

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global food problem and is a valuable source of protein. According to the Food and Agriculture Organization of the United Nations (FAO), over the past ten years, the soybean area in the world increased from 102.4 million hectares in 2010 to more than 120 million hectares, as of 2021 [12, 13]. But it should be noted that along with the increase in sown areas over the years, there is a tendency to its yield reduction. This is due to a number of environmental factors, in particular, the aridization of climatic conditions, a decrease in soil fertility, the resistance of harmful organisms to modern methods of their control, etc. [14–16]. Among legumes, an important place belongs to species of the genus *Vigna*. Representatives of this genus are now of considerable interest among scientists-introducers and breeders [17, 18]. Plants of the genus *Vigna* are characterized by a fairly long history of consumption as a valuable food [19], fodder [20], and industrial crop [21]. A large amount of biologically active compounds (micro- and macroelements, vitamins, etc.) accumulate in the above-ground part of them [22], and the seeds are a source of protein, the content of which is from 22 to 28% [23]. Compared, for example, with such well-known crops as soybeans and beans, this is approximately 1.5 [24] and 3.0% [8] less, but exceeds chickpeas by 1.5–2.0% [25] and 1.6–1.9% of lentils [9].

It is known that species of the genus *Vigna* are characterized by a high adaptive capacity to environmental conditions, therefore, in countries with impoverished soils, they are widely used as a vegetable crop: above-ground phytomass (immature beans) are used as a substitute for traditional salad crops, in particular asparagus, and ripe seeds – legume-cereal crops [26]. Like all other traditional legumes, it is a source of relatively cheap, vital protein to meet the needs of the human and animal body. Ripe seeds, such as *Vigna subterranean* L., together with *Zea mays* L., are also used to make protein bars, which are characterized by a fairly long shelf life and energy value [27].

Today, plants of the genus *Vigna* have proved themselves as a valuable source of raw materials for food and fodder use in many countries. There is a tendency to assess the species composition, as well as the varieties created on their basis, in terms of resistance to environmental stress factors, productive potential, and the possibility of comprehensive use in agriculture [28, 29].

In Ukraine, in recent years, there has been a tendency to expand the range of representatives of the genus *Vigna* [30–32], while this

genus still remains little-studied. Therefore, the creation and replenishment of the domestic gene pool, the conduct of comprehensive introduction studies, the selection of promising samples for further breeding work will significantly expand the range of economically valuable plants focused on the development of the agro-industrial sector and improving the quality of life of a society.

The aim of the research is to conduct a comprehensive study of the morphological characteristics of plants of the genus *Vigna*, to assess the productive potential depending on the species characteristics under the conditions of introduction in the Right-Bank Forest-Steppe of Ukraine.

Materials and methods

The studies were carried out during 2019–2021 on the experimental breeding plots of the department of cultural flora of the M. M. Gryshko National Botanical Garden of the National Academy of Sciences of Ukraine, located in the zone of the Right-Bank Forest-Steppe of Ukraine.

The soils of the experimental plots were gray forest podzolic. The depth of the arable layer was 20–22 cm. The content of humus in the soil was 3.26%, pH is 6.7, nitrogen content was 98 mg/kg, phosphorus is 373, and potassium – 66 mg/kg of soil.

Introduced plants of four species of the genus *Vigna*: *V. radiata* (L.) R. Wilczek, *V. angularis* (Willd.) Ohwi & H. Ohashi, *V. mungo* (L.) Hepper, *V. unguiculata* (L.) Walp. were the material for the study.

The main method of work was a comparative morphological analysis of plants grown from seeds during the growing season according to the phases of development following the guidelines of I. P. Ignatieva [33].

When describing the shape of leaves, stems, roots, flowers, inflorescences, fruits and seeds, the terminology given in [34] was used; for a comparative description of plants, the terminology according to the works of I. G. Serebryakov and T. I. Serebryakova [35–37] was used.

Phenological observations were carried out by recording the phases of development with an interval of 3–5 days according to the method of I. M. Beydeman [38], G. M. Zaytsev [39] and the Method of Phenological Observations in the Botanical Gardens of the USSR [40]. The beginning of the phase was determined in the presence of the trait in 10%, and the complete phase was determined in 75% of the plants.

The yield of above-ground mass was taken into account according to the method of G. M. Zaytsev [41]. The actual seed productivity was

determined by the number of mature seeds. Samples were collected at the same degree of maturity. The biological characteristics of the seeds were studied using the Atlas of seeds and fruits of Central and East European flora (The Carpathian Mountains Region) [42]. When determining the uniformity of seeds, their viability and the weight of 1000 seeds, we used the international rules for seed analysis [43], State standard (DSTU) 2949-94 «Seeds of agricultural crops. Terms and Definitions».

The obtained research results were processed by the methods of dispersion analysis and statistical evaluation of average data using Microsoft Excel (2010).

Results and discussion

It was revealed that the introduced species of the genus *Vigna*, gathered in the collection of the department of cultural flora, are annual plants. It should be noted that in the scientific literature, no attention was paid to the study of the morphometric parameters of seeds of the genus *Vigna* plants, although these indicators are important for plant breeding. It was established that, according to morphometric parameters, among the studied introduced species, *V. unguiculata* was characterized by the largest linear dimensions and weight of 1000 seeds, while *V. mungo* was the smallest (Fig. 1).

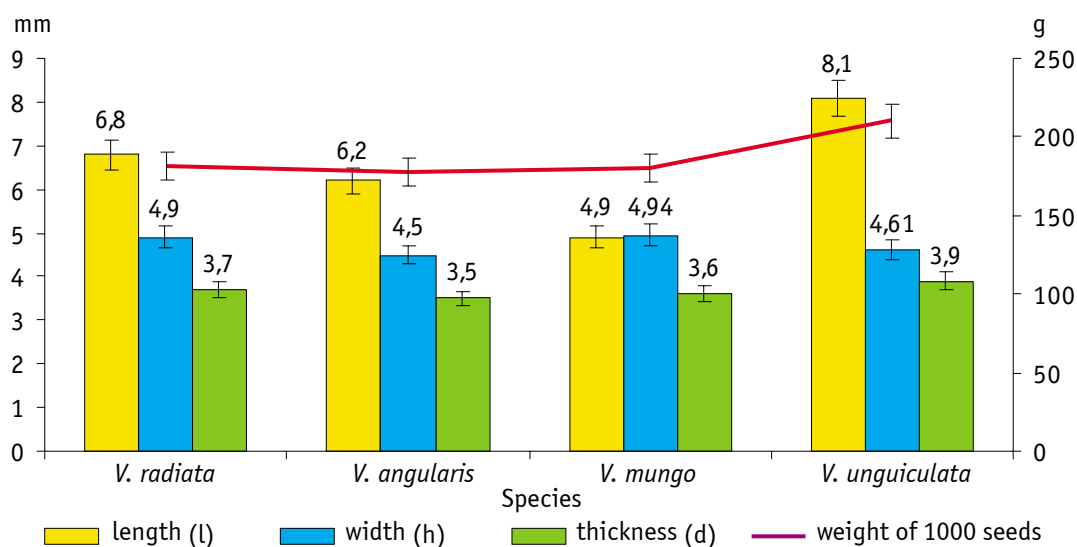


Fig. 1. Size and weight of 1000 seeds of species of the genus *Vigna* under the conditions of introduction at the M. M. Gryshko NBS of the NAS of Ukraine

Along with the size and weight of seeds, their morphological features (shape, color of the seed coat and endosperm, etc.) are also important [44]. It was revealed that the seeds of the genus *Vigna* species are characterized by heterogeneity of morphological features depending on the plant species. According to the shape of the seeds in all species, they are predominantly kidney-shaped (view from the side) and elliptical (view from the side of the hilum). In the transverse section of the medial part of the seeds, a number of important characters that distinguished the species from each other were identified. In view of this, the introduced species were divided into the following groups: according to the shape of the cross section of seeds (ovoid – *V. angularis*, *V. mungo*, rounded – *V. radiata*, heart-shaped – *V. unguiculata*); according to the placement of the hilum relative to the surface of the seeds (concave – *V. angularis*, *V. mungo*, even – *V. unguiculata*, convex – *V. radiata*). In all introduced species, the seed

coat is hard, smooth and shiny, red (*V. angularis*), green (*V. radiata*), gray with spotting (*V. mungo*), light brown (*V. unguiculata*) color. The endosperm is white with a hint of the seed skin color. The hilum is white; it mainly ensures the permeability of water and nutrients to the seed embryo (Fig. 2).

One of the most important indicators of seed quality is germination and germination energy. The similarity of seeds is determined by its ability to form well-developed seedlings, and the germination energy is determined by the ability for rapid and simultaneous seed germination, what characterizes its viability [43]. Among the studied introduced species *V. angularis* had the highest seed germination, *V. unguiculata* had the highest germination energy, and in other species these indicators are somewhat lower (Fig. 3). It should be noted that, compared, for example, with the studies of N. A. Ravshanova [45], under the condition of introduction in the Right-Bank Fo-

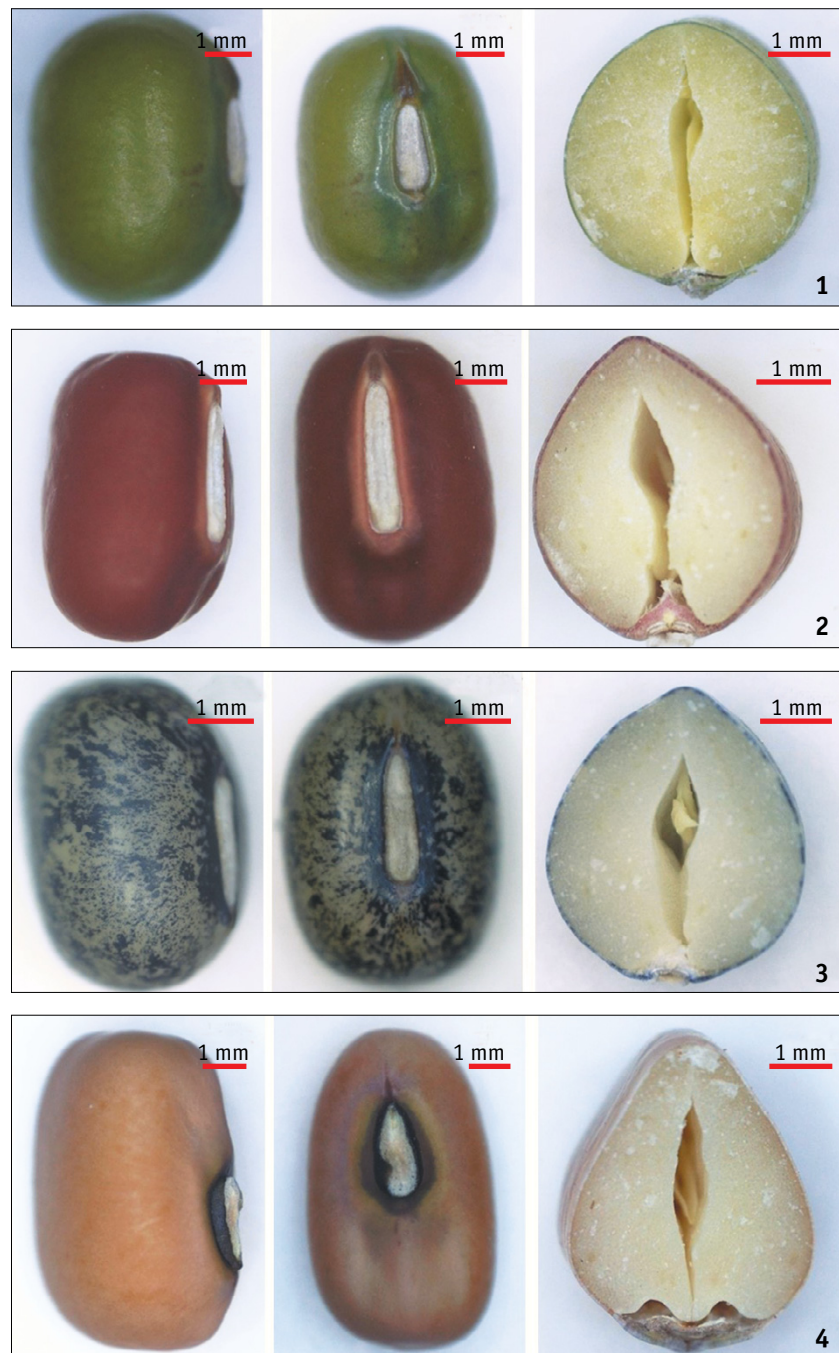


Fig. 2. Morphology of seeds of the genus *Vigna* species:

1 – *V. radiata*, 2 – *V. angularis*, 3 – *V. mungo*, 4 – *V. unguiculata*

rest-Steppe of Ukraine, plants provide approximately 25–35% higher seed germination.

The study of morphological indicators depending on the phase of development allows not only to establish the general and distinctive features of plants, but to assess the productive potential of the introduced species. It was found that representatives of the genus *Vigna* are characterized by significant variability of biometric characteristics (Fig. 4). For example, in adult generative plants (fruiting phase), when the growth of vegeta-

tive organs stops, the linear dimensions of the shoot varied on average from 58.13 (*V. angularis*) to 172.05 cm (*V. unguiculata*), the root system – from 13.9 (*V. mungo*) to 28.4 cm (*V. unguiculata*). The smallest root collar diameter was observed in *V. angularis* (6.11 mm), the largest in *V. mungo* (15.22 mm). Comparing with the results obtained by A. S. Bagdalova [46], it should be noted that the biometric indicators of the representatives studied by us are approximate with a slight excess.

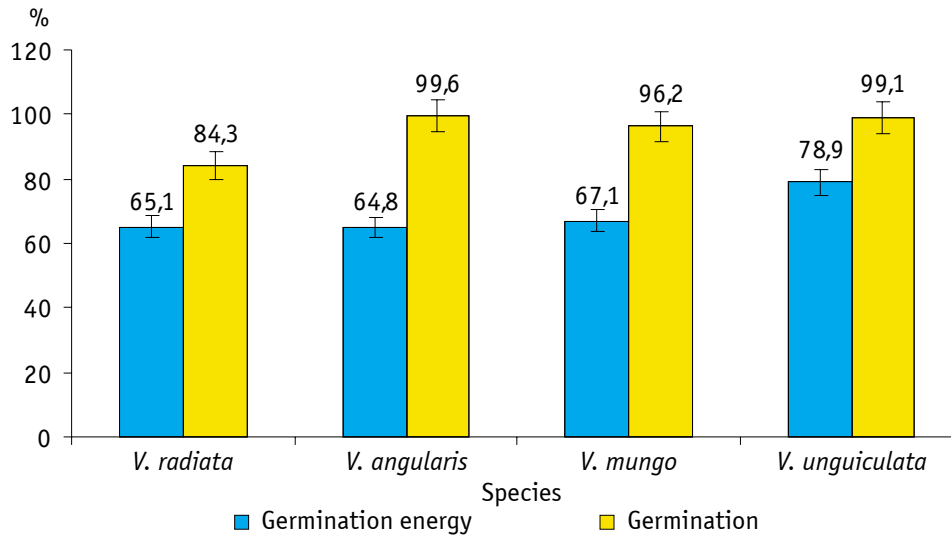


Fig. 3. Germination energy and seed germination of plants of the genus *Vigna* depending on species characteristics

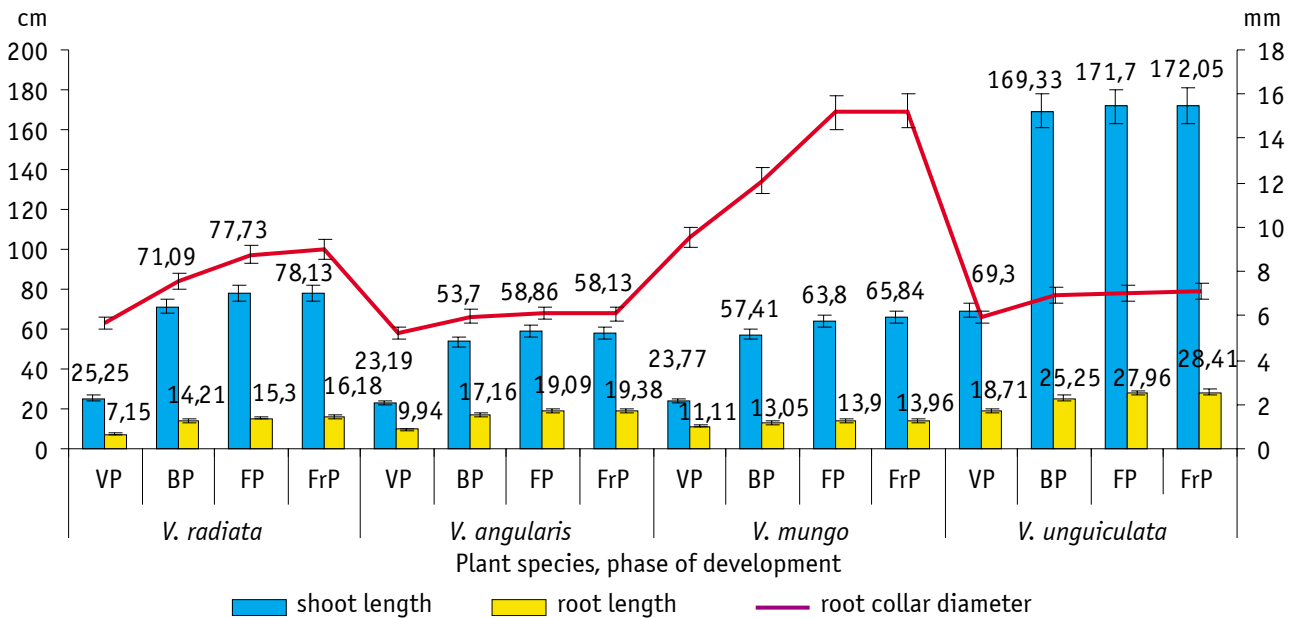


Fig. 4. Biometric indicators of the terrestrial and underground parts of plants of the genus *Vigna*, depending on the species characteristics and phase of development:
 VP – vegetative phase, BP – budding, FP – flowering, FrP – fruiting

All introduced species actively grew leaf mass. Together with an increase in the linear dimensions of the shoot, an increase in the number of leaves and their linear parameters was observed. An active increase in the biometric parameters of the leaf occurred between the phases of growth and flowering of plants, then growth stopped, and all metabolic processes were directed to the formation of the crop. Among the studied introduced species, *V. radiata* (44.10 cm) was characterized by the largest linear dimensions of the lower leaves, *V. unguiculata* (22.12 cm) was the smallest. The same pattern was typical for leaves of the middle and upper tiers (Table 1). Comparing

with the results of studies under the conditions of introduction in the Lower Volga region [46], it should be noted that plants under the conditions of introduction in the Right-Bank Forest-Steppe also provide relatively higher parameters of the leaf blade.

It is known that the study of the number of flowers and pods per plant makes it possible to determine their potential and actual productivity [47]. For representatives of the genus *Vigna*, this issue has not been given attention to date, so we decided to study these features. Thus, it should be noted that all plants simultaneously entered the phase of flowering and fruiting, which, in turn, ensured good pollina-

Table 1
Biometric indicators of the leaf blade* in plants of the genus *Vigna* when introduced in the Right-Bank Forest-Steppe of Ukraine

Species	Development phase	Leaf blade length, cm		
		lower	middle	upper
<i>V. radiata</i>	VP	22.09 ± 0.33	21.17 ± 0.10	8.77 ± 0.07
	BP	37.04 ± 0.12	29.05 ± 0.03	20.76 ± 0.11
	FP	42.55 ± 0.07	31.58 ± 0.16	21.23 ± 0.15
	FrP	44.10 ± 0.21	31.13 ± 0.04	22.02 ± 0.09
<i>V. angularis</i>	VP	16.40 ± 0.17	9.88 ± 0.07	4.06 ± 0.04
	BP	28.32 ± 0.31	17.50 ± 0.11	9.31 ± 0.03
	FP	30.04 ± 0.13	19.91 ± 0.18	10.03 ± 0.01
	FrP	30.97 ± 0.03	19.28 ± 0.20	10.15 ± 0.07
<i>V. mungo</i>	VP	15.79 ± 0.15	7.31 ± 0.09	4.34 ± 0.02
	BP	29.55 ± 0.10	15.16 ± 0.07	11.08 ± 0.06
	FP	31.00 ± 0.31	16.17 ± 0.10	13.01 ± 0.04
	FrP	31.31 ± 0.24	16.32 ± 0.01	13.45 ± 0.12
<i>V. unguiculata</i>	VP	9.66 ± 0.11	8.09 ± 0.03	4.11 ± 0.05
	BP	20.22 ± 0.18	14.76 ± 0.16	7.07 ± 0.02
	FP	22.03 ± 0.14	17.81 ± 0.11	9.11 ± 0.03
	FrP	22.12 ± 0.10	18.83 ± 0.03	10.59 ± 0.13

*10 plants of each species were analyzed in quadruple replication.

Note. VP – vegetative phase, BP – budding, FP – flowering, FrP – fruiting.

tion of flowers. In almost all representatives, the number of formed pods corresponds to the number of flowers. The difference between the potential and actual productivity of plants was fixed within 1% for *V. unguiculata*, which is most likely due to the creeping development

strategy of the shoot system, and as a result some flowers become inaccessible for pollination by insects. For *V. radiata* plants, this difference is obviously related to the fact that the flowers of the upper tier are small and poorly developed; therefore, pods do not develop (Fig. 5).

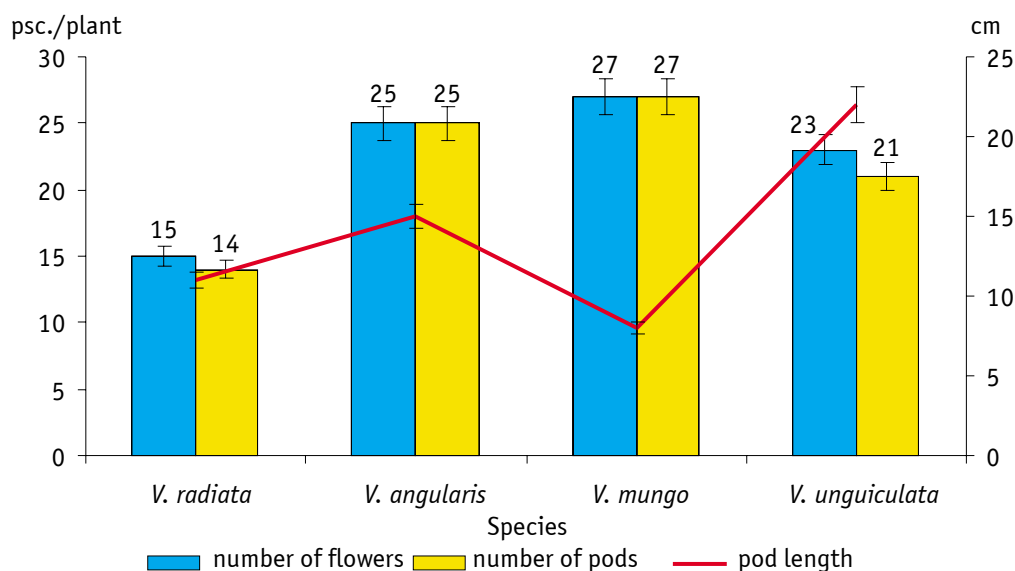


Fig. 5. Biometric indicators of generative organs of plants of the genus *Vigna* species

It has been revealed that the duration of the vegetation period for plants of the genus *Vigna* averages from 64 (*V. radiata*) to 75 days (*V. unguiculata* and *V. angularis*). Regarding the issue of the yield potential of plants of this genus, little attention has been paid in the scientific literature, mainly investigations are aimed at studying the productive indica-

tors of green beans [48, 49]. Since one of the most important indicators reflecting the overall productivity of plants is seed productivity, we paid attention to this in our studies. Thus, it was found that *V. unguiculata* plants provide the highest indicators of seed productivity – within 564 g/m², the lowest indicators were recorded in *V. radiata* (Table 2).

Table 2

The duration of the growing season and the seed yield of plants of the genus *Vigna* species when introduced in the Right-Bank Forest-Steppe of Ukraine

Species	Duration of the growing season, days	Seed productivity, g/plant	Seed yield, g/m ²
<i>V. radiata</i>	64 ± 3.6	36 ± 1.7	468 ± 9.10
<i>V. unguiculata</i>	75 ± 1.5	47 ± 1.1	564 ± 10.25
<i>V. angularis</i>	76 ± 1.5	43 ± 1.3	516 ± 5.80
<i>V. mungo</i>	69 ± 1.0	45 ± 0.9	585 ± 5.01

Conclusions

The morphological features of seeds, above-ground and underground organs of plants of the genus *Vigna* species were studied depending on the species characteristics and phase of development; their productive potential was clarified when introduced into the Right-Bank Forest-Steppe of Ukraine.

It was revealed that the studied introduced species under culture conditions are characterized by a fairly high germination (in particular, *V. angularis* – 99.6%) and germination energy (in particular, *V. unguiculata* – 78.9%) of seeds. It was found that the duration of the growing season in plants is on average from 64 (*V. radiata*) to 75 days (*V. unguiculata* and *V. angularis*). All species provide high seed yield (the highest in *V. unguiculata* – 564 g/m²). Among the studied species of the genus *Vigna*, the highest productivity (including green phytomass) in all years of research was produced by the introduced species *V. unguiculata*. In this regard, these species can be used in breeding studies in order to expand the potential of the raw material base in addition to traditional legumes and cereals.

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Бондарчук О. П.*, **Рахметов Д. Б.**, **Вергун О. М.**, **Рахметова С. О.** Морфологічні особливості та продуктивний потенціал рослин роду *Vigna Savi*. в умовах Правобережного Лісостепу України. *Plant Varieties Studying and Protection*. 2022. Т. 18, № 1. С. 4–13. <https://doi.org/10.21498/2518-1017.18.1.2022.257582>

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Мета. Провести комплексне дослідження морфологічних особливостей рослин роду *Vigna*, оцінити їх продуктивний потенціал залежно від видових особливостей за умов інтродукції в Правобережному Лісостепу України. **Методи.** Основний метод роботи – порівняльний морфологічний аналіз рослин, вирощених із насіння. Дослідження проводили на інтродукційних ділянках та в лабораторних умовах відділу культурної флори Національного ботанічного саду імені М. М. Гришка НАН України впродовж 2019–2021 рр. Матеріалом для досліджень слугували рослини чотирьох видів роду *Vigna*: *V. radiata* (L.) R.Wilczek, *V. angularis* (Willd.) Ohwi & H. Ohashi, *V. mungo* (L.) Hepper, *V. unguiculata* (L.) Walp. Вивчали закономірності проходження ростових процесів і розвитку рослин залежно від видових особливостей. Визначали ґрунтову схожість насіння без попередньої підготовки залежно від видових особливостей. Використовували польові, лабораторні а також методи дисперсійного аналізу і статистичної оцінки середніх даних з використанням програми Microsoft Excel (2010). **Результати.** Виявлено, що насіння рослин

V. radiata, *V. angularis*, *V. mungo*, *V. unguiculata* за інтродукції в Правобережному Лісостепу України характеризуються високим рівнем енергії проростання (від 64,8% у *V. angularis* до 78,9% у *V. unguiculata*) та схожості (від 84,3% у *V. radiata* до 99,6% у *V. angularis*), інтенсивністю росту й розвитку наземних і підземних органів упродовж вегетації та продуктивністю насіння (від 468 г/м² у *V. radiata* до 585 г/м² у *V. mungo*). Це свідчить про перспективність їх культивування як вихідного матеріалу для селекційних досліджень та доцільність для використання у рослинництві, що дасть змогу розширити потенціал сировинної бази в доповнення традиційним бобово-злаковим культурам. **Висновки.** Вивчено морфологічні характеристики насіння, вегетативних та генеративних органів рослин видів роду *Vigna*. Установлено особливості формування продуктивності насіння, наземної та підземної частини рослин впродовж вегетації залежно від видоспецифіки в умовах інтродукції в Правобережному Лісостепу України.

Ключові слова: види роду *Vigna*; інтродукція; продуктивність; морфологічні особливості.

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