Ukrainian Journal of Ecology

Ukrainian Journal of Ecology, 2022, 12(8), 12-19, doi: 10.15421/2022_394

ORIGINAL ARTICLE

Morphological and ecological features of green pea (*Pisum sativum* L.)

S. Poltoretskyi[1], V. Karpenko[1], V. Liubych[1], N. Poltoretska[1], V. Bilonozhko[2], H. Demydas[3]

[1]Uman National University of Horticulture (Uman), Cherkasy region, Uman, st. Instytutska, 1-20305, Ukraine

[2]Bohdan Khmelnytsky National University of Cherkasy (Cherkasy), Bul. Shevchenko, 81-18031, Ukraine

[3]National University of Life and Environmental Sciences of Ukraine (Kiev), st. Heroiv Oborony, 15-03041, Ukraine

**Corresponding author E-mail: poltorec@gmail.com*

Date of Submission: *04 February, 2021; Manuscript No: UJE-21-25683;* ***Editor assigned:*** *07 February, 2022, PreQC No: P-25683;* ***Reviewed:*** *18 February, 2022, QC No: Q-25683;* ***Revised:*** *22 September, 2022, Manuscript No: R-25683;* ***Published:*** *30 September, 2022.*

An analytical review of literature sources on the spreading area, world acres and gross collection, nutritional and fodder value of pea was given. The state of studying the issue on classification and species diversity of green pea (*Pisum sativum* L.) was given. It was established that green pea was an important agricultural crop of world agriculture, which was inferior only to grain cereals in terms of production volume and was characterized by a significant variety of morphological forms. Despite the considerable long period of cultivation and research, a number of issues on the centers of origin, classification, genetic diversity and ecological-and-morphological features of this crop remains controversial even now among researchers and practitioners and needs further study.

Keywords: Pea, Classification of species, *Pisum sativum* L., Forms, Features, Morphology of plants and seeds.

Introduction

At present, grain legumes are inferior only to cereals in terms of production volume. The family *Fabaceae*, which includes five genera: *Pisum, Vavilovia, Lathyrus, Vicia* and *Lens,* has the largest number of cultivated grain legumes (pea, pea vine, lentil, vetch, etc.). One of the leading places in agricultural production is occupied by green pea (*Pisum sativum* L.) among the representatives of this family, it is one of the main legumes of world agriculture. Like all legumes, pea contains a large amount of protein (23-25%), slowly digestible starch, fiber, vitamins and minerals, and also is a source of antioxidants, anti-inflammatory substances, carotenoids, omega-3 and omega-6 of fatty acids (Bastianelli D., et al., 1998; Dahl W.J., et al., 2012).

Green pea has a fairly wide area of cultivation in different agro-ecological regions of the world. Thus, its natural area extends from Iran and Turkmenistan, through Asia Minor, North Africa and southern Europe (Makasheva R.Kh., 1979; Jing R., 2012). It is now difficult to determine the exact location of the center of origin of this crop, although, due to ancient human domestication, and taking into account that much of the Mediterranean region and the Middle East was greatly changed by human activities and climatic conditions (Maxted N., et al., 2010).

According to the FAO data, nowadays the annual world production of green pea (marrowfat and sugar varieties) and shell pea is more than 17 and 11 million tons, respectively (Rawal V., Navarro D.K., et al., 2019). The leaders in pea production are Canada, France, Russia and China. The sown areas under pea and its gross production in Ukraine in 2018 was 431.4 thousand ha and 774.9 thousand tons, and in 2019 these indicators decreased to 243.4 thousand ha and 583 thousand tons, respectively according to the

State Statistics Service (2019, 2020).

Pea has been grown for over 10 000 years. It has been the subject of a great number of researches over the past six centuries, including the works of Gregor Mendel. However, to this day, a large number of questions remain about the origin and diversity of pea species, their morphological-and-physiological and ecological-and-biological features, the formation of optimal conditions of growing for both food and fodder purposes.

The purpose of this study is to substantiate theoretically and determine the optimal agroecological conditions for the formation of the largest yield of green pea of different morphotypes.

Results and Discussion

Pea genus (*Pisum* L.) has wild and cultivated species. Despite the small volume of this genus, its species composition is constantly changed. Thus, according to the classification of L. I. Govorova (1937), the *Pisum* L. genus consists of six species: *P. sativum* L., *P. formosum* (Stev.) Alef., *P. elatius*, *P. himile* Boiss et Moe., *P. fulvum* Sibth., *P. abyssinicum* Broun.

However, according to the classification of R. Kh. Makashevoy (1971, 1973) this genus includes only two species: *P. fulvum* Sibth. Et Smith. -red-yellow pea (wild, one-year, rocky) and *P. sativum* L.-green pea (cultivated). The *P. sativum* L. species consists of six subspecies: subsp. *elatius* (Bieb.) Schmalh. or tall; subsp. *syriacum* (Boiss. et Noe) Berger or Syrian; subsp. *abyssinicum* (A. Br.) Berger or Abyssinian; subsp. *transcaucasicum* Makash. or Transcaucasian; subsp. *asiaticum* Govorov or Asian; subsp. *sativum* or green pea.

However, scientists often combined or separated two species-green (*P. sativum* L.) and field (*P. arvense* L.), which is often called a field pea (Vaughan J.C., Geissler C.A., 2009, Diachenko, et al., 2014). Others combined these two species under different names: *P. vulgare* Jundz. (Jundzill J., 1830; Fingerhuth K., 1836; Dierbach J., 1839); *P. commune* Clav. (Clavaud A., 1884); *P. sativum* L. (Alefeld F., 1866; Koernicke F., 1873; Kaznowski L., 1926; Gams H. in Hegi G., 1924; Govorov L. I., 1937; Zhukovsky P.M., 1964; Chr.O. Lehmann, 1954; Fedotov V.S., 1960); *P. arvense* L. (Lamprecht H., 1956, 1970) (quotation by Makashevoy R.Kh., 1979).

Green pea is a one-year spring or wintering plant with a taproot that penetrates the soil to 1.5 m and deeper. The plant has the vast majority of well-branched (up to 1.0 m) lateral roots in the upper layer of soil (up to 0.40 m), which are often difficult to distinguish from the main root by appearance, as well as a large number of small roots (Wozowick I.S., 1983; Gareev D.B., et al., 1997). Bubbles are formed in the places of penetration of nitrogen-fixing bacteria (Rhisobium leguminosarum) into the roots. These bacteria are able to absorb free nitrogen from the air and synthesize physiologically active substances, including vitamins of group B (Borisov A. Yu., 2011).

The pea stem is rounded or indistinctly quadrangular, hollow inside, of different thickness (from medium to thick), internodes are from short to long (Fadeeva A.N., Shurkhaeva K.D., 2007). Stems in pea can be simple (ordinary) and fasciated (standard). Simple stems have elongated internodes, thin to the top, flowers and beans are fairly evenly spaced at a certain distance from each other. Fasciated stems consist of short internodes, expanded-and-flattened (fasciated) in the upper part, the nodes are close, flowers and beans are clustered. The lower part of such stem is not fasciated, so it lies down easily (Ellis T.H., et al., 2011).

The growth type in pea is determinate (limited) and indeterminate (unlimited). The determinate type of growth is characterized by the fact that the generative organs are formed only in the upper part of the stem and the growth point ends with a generative bud in contrast to the indeterminate samples, in which stem growth continues in the presence of beans at the lower nodes (Bezugla O.M., et al., 2014).

Currently, three types of determinism are known in pea-Moscow, Luhansk and Samara. The Moscow type is phenotypically manifested by the formation of two to five productive nodes, after the formation of which the plant fully completes its growth. Two carpophores come from the last node. There is no growth point. There is no vegetative bud or leaf on the last node; seeds in plants of this type of determinism are rugate (Makasheva, R.Kh., Drozd A.M., 1987; Batashova M.E., 2005).

The Luhansk type of determinism is phenotypically similar to the Moscow type, but only one or two productive nodes are formed on the plant. The seeds have a rounded shape with a smooth surface.

The Samara type is phenotypically different from the previous ones-one to nine (usually three to five) productive nodes are formed on plants. There is a decrease in the length of the internode in the generative part of the stem. Leaves are underdeveloped or almost absent at the productive nodes. A strongly reduced bud falling quickly in the field conditions is next to the upper

inflorescence. This is the so-called "physiological type" of determinism, which is characteristic of most now common in the production of pea varieties (Batashova M.E., 2005).

The length of the stem varies from 20 to 300 cm depending on the varietal characteristics and growing conditions. The height of plants from a genetic point of view is determined by two factors-the number of internodes and their length (Hangildin V.V., 1971). Low stems (dwarfs) are below 50 cm, semi-dwarfs-51-80 cm, medium-grown-81-150 cm, tall-growing-151-300 cm. A node is called a place of attachment of the leaf petiole and stipule to the stem, and the area of the stem between the nodes is called an internode. Nodes from the first lower leaf to the first flower (or bean) are defined as unproductive. Their number on the main stem is a relatively stable varietal feature, which can be indirectly characterized by the duration of the vegetation period. Thus, early varieties have 7-11 unproductive nodes, medium-ripe varieties-12-15, and late-ripe varieties-16-21 (Gorin L.P., 1956; Makasheva R.Kh., 1975, 1979; Kirichenko V.V. et al., 2009). Lateral branches are subject to this only if they branch out from the lower node. The closer to the base of the main stem the lateral branch is formed, the more unproductive nodes are formed on it (the heteroramy phenomenon). The nodes from which the flower or bean branch out are called productive (fertile). The number of fertile flowers significantly depends on growing conditions compared to the number of unproductive nodes.

The stipules in colour-flowered forms are larger than the leaves, have a semicordate shape and almost serrated edges by ⅓ Sometimes mutant forms of pea in the axilla of the stipule have an anthocyanin semi-ring or a small colored spot. Such semi-ring can be double in some forms (sometimes only on some nodes). There may also be cases when the next ring is narrow with a faint yellow-green colour after the anthocyanin semi-ring which is located in the tangential to the stem part of the axilla of the stipule (Gareev D.B., et al., 1997).

Mainly, pea leaves are paripinnate consisting of a petiole and one to three pairs of leaves and an odd number of tendrils (three, five, seven). Less often, the leaf ends with an odd leaf (tendrilless, acacia-like or multi-leaf), then their total number is 7-15. Very rarely, the leaf is repeatedly odd-pinnate ends in an odd one, very small leaf (Clemente A., et al., 2004; Clemente S.L., et al., 2004). Sometimes it is completely without leaves-in this case, the petiole turns into a strongly branched main vein with imparipinnate tendrils (tendrilled or leafless morphotype). Pea scrambles to any support with the help of tendrils, owing to this its creeping stem can grow vertically. For the first time (1953) this morphotype was obtained in Finland by V. Rujala, and a little later (1958) in the USSR by V.K. Solovyov (independently of each other). Currently, most of the world's cultivated varieties of green pea belong to the whiskered morphotype (Bezugla O.M., et al., 2014).

The shape of the leaves can be different-rounded, elongated, ovate, inverted ovate, broadly ovate, with a large number of transitional shapes between them. The edges of the leaf are entire, serrated, sawed, sawed-and-serrated, intermittently-and-serrated, intermittently-and-sawed, crenate (Makasheva R.Kh., 1975, 1979). The number of leaves and tendrils in the productive part of the stem is larger and fairly constant, and less within the unproductive nodes.

The colour of the leaves is a varietal feature. However, it may vary depending on the stage of the plant and leaf development, the level of soil fertility and fertilizers applied to the crop or predecessor. There is yellowish-green, light green, green, dark green and gray-green colour. Very rarely, the leaves on a green background have as if sprayed anthocyanin dots-"spots" (Govorov L.I., 1937; Fedotov V.S., 1960; Zhukovskiy P.M., 1964; Krylatova S.A., Lurie B.D., 1964; Gareev D.B., et al., 1997).

Pea stipules are usually larger than the leaves. However, there are forms in which the stipules are reduced. There are the following forms of stipules-ordinary, rudimentary and "rabbit ears" (Fadeeva T.S., Burenin V.I., 1990; Bezugla O.M., et al., 2014). The stipules and leaves usually have a silvery-gray mosaic pattern formed by the air in the intercellular spaces of the tissues, usually more manifested on the stipules. The size of the spots, the density of their location is varietal characteristics. The absence of spots or their great number, almost complete, gray mosaic is noted only in rare forms of pea.

The pea plant is usually covered with a waxy coating, which performs a protective function against insects and fungal diseases (Kirichenko V.V., et al., 2009). However, some forms can be without it. In this case, the green colour of the stem, petioles and leaves acquires a bright emerald shade. Also, quite rarely, there is a strong waxy coating, and then the plant seems to be silvery-gray.

A number of non-traditional morphotypes by the leaf architectonics: acacia-like, tendril acacia, repeatedly imparipinnate, chameleon, dissected-leaf, twice imparipinnate in addition to traditional forms in the genofond of the *P. sativum* L. genus was found. They are not yet widespread in agricultural production, but according to some researchers, almost all non-traditional morphotypes of pea

have a high potential of biological and some-and seed productivity (Zelenov A.N., Shelepina N.V., Mamaev M.V., 2013).

Thus, odd-pinnate (acacia-like) leaf shape has no tendrils and ends with an odd leaf. It was obtained almost 100 years ago in France (Akatsievydnyi (Acacia-like) 1 variety, Ukraine). Repeatedly odd-pinnate form has repeatedly branched shortened tendrils ending in small leaves. It was got by crossing a whiskered and acacia-like form (Vytiaz variety, Ukraine). Chameleon has leaves with leaves and several unbranched tendrils on four-five lower nodes, forms whiskered leaves in the middle tier on four-six nodes, leaves with repeatedly branched tendrils and unevenly placed leaves on them (Spartak variety, Russian Federation) in the upper tier (Zelenov A.N. et al., 2008).

Inflorescence in pea is tassel; a false umbel is in fasciated forms (Bryzgalov V.A., 1982). Flowers, one-two, rarely two-three or more, are placed on a long peduncle coming from the axilla of the stipule. Multi-flowered is a valuable selection feature that directly correlates with multi-fertility and affects the yield of pea. The peduncle has anthocyanin pigmentation in some colour-flowered forms of pea; it is yellow (waxy) very rarely. The length of the peduncle is a relatively stable feature that usually correlates with the length of the stipules. There is a very short peduncle (almost sessile)-almost ⅓shorter than the stipules, and much longer than them (almost two or more times). The fruit stem in colour-flowered forms may have another colour than the peduncle (for example, the peduncle is green, and the fruit stem is with anthocyanin colour or vice versa). In addition, a clearly visible red-purple spot is already in the initial stages of growth in the axilla of the stipule in such forms of pea.

In 1991, V. N. Uvarov (1993, 1995) found a plant with the inflorescence similar to that, in lupine. The established analogy is reflected in the name of a new form-"lupinoid". A distinctive feature of this form is the presence of an apical thickening of the peduncle with up to 11 flowers placed alternately sitting on short floral stems.

Pea flower is of butterfly type, five-membered, 1.3 to 3.5 cm in size. Calyx consists of five sepals, corolla-of five petals: vexillum-the upper largest of all petals; wing petals-lateral free (not concrete) petals; slipcover-is formed by two petals, partially concreted. The projection so-called keel is usually formed at the junction of the petals of a slipcover. A wing petal in shape is inverted-broadly ovoid or narrowed, as if cut at the bottom. It has a small, medium-sized or fairly deep depth (it is absent rarely) in the middle. There is a small shoot in its center, sometimes there are forms without it (Meunissier A., 1922; Rasmusson J., 1935; Rowlands D., 1964).

The wing petals are elongated-crescent-shaped, their extended part is either very wide (width is much greater than length) or almost rounded (relatively equal in width and length) or narrowed (length is greater than width).

The vexillum is usually white, but has relatively intensive anthocyanin pigmentation or only the keel, or on the sides in some colour-flowered forms (Makasheva R. Kh., 1979).

The colour of the corolla is usually determined by the wings: it is white in the varieties of cereals or vegetables; pink, red-purple, crimson (dull purple), red-violet, terra-cotta-red, greenish-red-violet of different intensity in the varieties of fodder or green-manured use. The vexillum compared to the wings is usually a little weaker in colour, sometimes they are almost the same (Makasheva R.Kh., 1962, 1973; Krylatova S.A., Lurie B.D., 1964; Khvostova V.V., 1975; Chekalin N.M., 1980; Bryzgalov V.A. et al., 1982).

The flower calyx in pea is connate, cup-shaped by form, swollen on top, with five teeth-the upper two are much wider than the lower three. The calyx has fairly noticeable anthocyanin pigmentation in some colour-flowered forms of pea.

In the pea flower, the androcea is double-breasted, it is formed of 10 stamens, nine of which grow together, and one remains free and is close to the ovary. A free stamen moves away from the ovary with little effort, opening access to the sugary fluid, which is released in the form of drops by glands located around the base of the ovary. Drops accumulate at the base of the free stamen, which deviates slightly from the ovary on both sides at the bottom, forming a small round hole. The ovary of the pea is almost sessile, the seed buds are formed up to 10-12 (Krylatova S.A., Lurie B.D., 1964; Chekalin N.M., 1980).

The androphore: cut obliquely; straight or slightly shorter than the ovary; bent almost at right angle inward at the base toward the ovary; enlarged, with curved downward edges, compressed at the top on the sides, pubescent on the inner lower side (Davletov F.A., 2015).

The fruit in pea is a bean which is formed from one carpophyl (carpel) and consists of two wings. There are hulling, semi-sugar and sugar forms of pea according to the structure of the wings. The wings have an inner hard so-called parchment layer consisting of two-three rows of woody and one-two rows of non-woody sclerenchyma cells in the first forms. Strips of parchment layer are available in the form of fibrous bundles in the semi-sugar forms, and bean wings do not have a parchment layer in the sugar forms.

The presence of a parchment layer causes light cracking of beans during drying and the absence-bad threshing (Govorov L.I., 1937; Makasheva R.Kh., 1971, 1973, 1979; Kirichenko V.V., et al., 2009).

The shape of the bean can be: straight with a blunt, pointed or elongated tip; slightly curved with a blunt or pointed tip; curved with a blunt or pointed tip; saber-shaped with a blunt or pointed tip; crescent-shaped with a pointed tip; concave with a blunt tip; bead-shaped (in sugar varieties) (Krylatova S.A., Lurie B.D., 1964; Gareev D.B., et al., 1997).

The bending degree of the bean can be used as a marker criterion. It is best to determine the shape of the bean during the period of technical maturity (filling phase), when beans reach the typical size for the variety at the level of the first-second productive node and contain filled soft green seeds, and there are no net on the bean wings which characterizes the completion of technical maturity (Makasheva R.Kh., 1973).

Beans can be small (3.0-4.5 cm long), medium (4.5-6.0 cm), large (6-10 cm), and very large (10-15 cm) (Govorov L.I., 1937). The number of seeds in the bean (bean fullness) varies from small (3-4 pieces), to medium (5-6) and large (7-12 pieces). Placement of seeds in the bean can be: loose (almost does not touch each other); medium-dense (touches but does not compress each other); dense (compresses each other); very dense (as if 2-6 pieces scrap together).

Seed size is one of the varietal characteristics (Krylatova S.A., Lurie B.D., 1964; Davletov F.A., 2017). The diameter of small seeds is 3.5-5.0 mm (weight of 1000 seeds is less than 150 g), medium-5.0-7.0 mm (150-250 g), large-7.0-10.5 mm (more than 250 g in round-seeded and more than 260 g-in angular forms).

There are three main forms of seed-round, oval and angular (Khvostova V.V., 1975; Polunin I.A., Litvinenko M.V., Arshinov V.I., 1977; Epikhov V.N., Tsyganok N.S., 1987). The surface of pea seeds is smooth, wrinkled, foveate. There are also transitional forms-round-angular, wrinkled-flattened and angular-wrinkled (marrowfat pea).

Seeds of wrinkled varieties are characterized by high content of sugars (up to 14.7%) and lipids, reduced content of legume and increased water absorption coefficient (up to 3.06%). In contrast, varieties with rounded seeds have a reduced content of sugars (up to 4.0%), lipids (up to 2.0%) and water absorption coefficient (up to 2.06%) (Kumari, N., Srivastava, J.P., Singh B., 2009; Vasilenko A.O., et al., 2011; Bezugla O.M., et al., 2014). However, surface fine-grained wrinkles may appear in some forms with smooth seeds during the ripening of pea with the alternation of dry and excessively moist conditions; it should be distinguished from the wrinkled surface of the marrowfat forms of seed. Under such conditions, wrinkling is really only surface, limited by the seed coat and does not pass to the cotyledon. The true wrinkling of the marrowfat seed extends to the cotyledon and is much larger. Sometimes hereditary wrinkles can be insignificant, but they must spread to the cotyledons.

The colour of the seeds can be light yellow, yellow, yellow-pink, orange, blue-gray, olive-green in white-flowered forms of pea (Makasheva R.Kh., 1962, 1973; Gorin A.P., 1976; Gareev D.B., et al., 1997). It mostly depends on the colour of the cotyledons which shine through the translucent, almost colourless seed coat. Sometimes the seed coat of the white-flowered forms of pea has separate greenish or yellowish areas. Because of this, there are cases of false metaxenia-yellow seeds are formed on the green-seeded plant during pollination of the varieties with green seeds by pollen of yellow-seeded forms.

The seed coat is more dense, non-transparent in colour-flowered forms, so the colour of the seed depends on the colour of the flower and the pattern of the seed coat, which is formed from the tissues of the mother's body.

The seed of pea varieties of grain use are usually light yellow, yellow-pink, rarely green, and very rarely orange (wax) or olive colour (Burstin J., et al., 2020).

Gray-green seed, sometimes yellow-green (two-coloured, when yellow and green areas alternate), yellow and very rarely-olive seed dominate in vegetable pea.

Green seed of a number of varieties easily turn yellow due to delays in plants threshing during the harvest or during its drying in areas open to the sun. The processes of normal formation of seed colour can be disrupted in yellow-seeded varieties during "burn" (early growth cessation and ripening from the heat), in such cases green seed may be formed (Fedotov V.S., 1960; Makasheva R.Kh., Khangildin V.V., 1990).

Seed of the varieties of fodder use (field pea) may have the following colour: solid brown (yellowish-gray, greenish-gray, yellow-gray, yellow-brown in freshly harvested and it becomes dark brown during storage); sometimes with a "blush" or yellow-red shade; crimson-red; from dark violet to almost black; single pattern-violet speckles, spotting (often dull), stripes in the form of violet smears of various sizes on a yellowish-brown and green background, brown marbling; double pattern-brown-marble combines with

violet speckles, spots or stripes.

All these types of seed colour are combined with the colour of the raphe. It is usually light (yellowish-white), very rarely black (never brown) in white-flowered forms of pea. Colour-flowered forms are characterized by brown (from light brown to dark brown) or black raphe (never light). Sometimes the pattern of seed is supplemented by the colour of chalaza, which can be light, brown or almost black (Makasheva R.Kh., 1975, 1979).

Pea seed consists of a germ and a seed coat. A hilum is easily visible on the seed-the place where the seed germ attaches to the wall of the ovary of the mother plant. The hilum is covered with aril, part of which is a seed stalk with a vascular bundle in the middle, through which nutrients come to the seed from the bean leaf. Micropile is placed at the end of the hilum on the side of the radicle through which the pollen tube penetrates during fertilization. Chalaza (in the form of a small nodus) which is the basis of the seed germ is situated on the opposite side of the hilum.

Two cotyledons which make up the vast majority of the embryo are under the seed coat. They concentrate spare nutrients for the growth and development of the main part of the embryo consisting of radicle, stem and embryonic apical bud. The embryonic radicle extends from the embryonic stem to the micropile, and the apical bud-in the opposite direction (Makasheva R.Kh., 1973, 1975, 1979; Chekalin N.M., et al., 1981, 2011).

Pea seed germination is underground; the cotyledons remain in the soil. The part of the stem from the seed to the first immature leaf is called the epicotyl. The radicle begins to grow first.

Conclusion

It is clear from the above review of literature sources that green pea (*P. sativum* L.) is characterized by a significant variety of morphological forms. Despite the considerable long period of cultivation and research, a number of issues on the centers of origin, classification, genetic diversity and ecological-and-morphological features of this crop remains controversial even now among researchers and practitioners and needs further study.

References

Ostapchuk, Y.M. (2009). Agriculture of Ukraine-Statistical yearbook. State Statistics Committee of Ukraine, Kiev, Ukraine.

Google Scholar

Bastianelli, D., Grosjean, F., Peyronnet, C., Duparque, M., Regnier, J.M. (1998). Feeding value of pea (*Pisum sativum* L.) 1. Chemical composition of different categories of pea. Animal Science, 67:609-619.

Google Scholar Crossref

Batashova, M.E. (2005). Inheritance of some marker traits of peas and their relationship with productivity. Institute of Plant Physiology and Genetics of NAAS of Ukraine. Poltava, p:20.

Bezugla, O.M., Kobyzeva, L.N., Vasilenko, A.A. (2014). Genetic collection of peas (*Pisum sativum* L.). Breeding and Seed Production, 105:104-122.

Borisov, A.Yu., Stark, O.Yu., Zhukov, V.A. (2011). Interaction of legumes with useful soil microorganisms: from plant genes to varieties. Agricultural Biology, 3:41-47.

Bryzgalov, V.A. (1982). A guide to vegetable growing. 2nd ed., revised. and add. Leningrad: Kolos, p:511.

Burstin, J., Kreplak, J., Macas, J. (2020). Pisum sativum (Pea). Genome of the Month, (April), 36:312-313.

Chekalin, E.I., Kondykov, I.V., Amelin, A.V. (2011). Stability of pea to extreme weather factors. New Varieties of Agricultural Crops-the Main Part of Innovative Technologies in Crop Production. Vestnik OrelGAU, 297:304.

Google Scholar

Chekalin, N.M., Korsakov N.I., Varlakhov, M.D. (1981). Selection of leguminous crops; under the editorship of A.V. Pukhalsky. Moscow: Kolos, p:336.

Clemente, A., MacKenzie, D.A., Johnson, I.T., Domoney, C. (2004). Investigation of legume seed protease inhibitors as potential anti-carcinogenic proteins. Publication-European Association for Animal Production, 110:137-142.

Clement, S.L., McPhee, K.E., Elberson, L.R., Evans, M.A. (2009). Pea weevil, *Bruchus pisorum* L.(Coleoptera: Bruchidae), resistance in *Pisum sativum*× *Pisum fulvum* interspecific crosses. Plant Breeding, 128:478-485.

Google Scholar Crossref

Crop production of Ukraine: statistical yearbook for 2019. (2020). State Statistics Service of Ukraine. Kyiv, p:183.

Dahl, W.J., Foster, L.M., Tyler, R.T. (2012). Review of the health benefits of peas (Pisum sativum L.). British Journal of Nutrition, 108:3-10.

Google Scholar Crossref

Davletov, F.A. (2017). Adaptive varieties of leguminous crops and the features of their seed production. Ufa: Bashkir State Agrarian University, p:35.

Davletov, F.A. (2015). Selection and technology of pea production in Bashkortostan. Ufa: World of the Press, p:164.

Dyachenko, E.A., Ryzhova, N.N., Vishnyakova, M.A., Kochieva, E.Z. (2014). Molecular genetic diversity of the pea (Pisum sativum L.) from the Vavilov Research Institute collection detected by the AFLP analysis. Russian Journal of Genetics, 50:916-924.

Google Scholar Crossref

Ellis, T.N., Hofer, J.M., Timmerman-Vaughan, G.M., Coyne, C.J., Hellens, R.P. (2011). Mendel, 150 years on. Trends in Plant Science, 16:590-596.

Google Scholar Crossref

Epikhov, V.A., Tsyganok, N.S. (1987). On the nature of the growth of vegetable peas. Fruit and Vegetable Industry. Moscow, 4:31-33.

Fadeeva, A.N., Shurkhaeva, K.D. (2007). Morphological features of modern pea varieties. Materials of the international scientific. Conf., 200th anniversary of the Kazan Botanical School. Kazan: Tatar Research Institute of Agriculture, pp:112-113.

Fadeeva, T.S., Burenin, V.I. (1990). Genetics of cultivated plants: legumes, vegetables, melons. Leningrad: Agropromizdat, p:287.

Fedotov, V.S. (1960). Peas. Moscow: Selkhozgiz, p:259.

Gareev, D.B. (1997). Characterization of varieties of agricultural varieties of agricultural crops included in the State Register for the Republic of Bashkortostan. Ufa, p:96.

Gorin, L.P. (1956). Features of biology and agricultural technology of pea culture in the Voronezh region: abstract of the dissertation of the candidate agriculture sciences. Voronezh, p:18.

Govorov, L.I. (1937). Peas. Cultural flora of the USSR; under the editorship of E.V. Wulfa. Moscow, Leningrad: Selkhozgiz, T, 4:229-236.

Jing, R., Ambrose, M.A., Knox, M.R., Smykal, P., Hybl, M., Ramos, A., Ellis, T.N. (2012). Genetic diversity in European Pisum germplasm collections. Theoretical and Applied Genetics, 125:367-380.

Google Scholar Crossref

Khangildin, V.V. (1971). Genetic principles of pea selection. Materials of the All-Union scientific and methodological meeting on selection and genetics of peas. UFA, p:30-40.

Khvostova, V.V. (1975). Genetics and selection of peas. Novosibirsk: Nauka, p:268.

Kirichenko, V.V., Kobizeva, L.N., Petrenkova, V.P., Ryabchuk, V.S., Markova, T.J. (2009). Identification of signs of leguminous crops (peas, soybeans). Institute of Planting of NAAS, Kharkov.

Krylatova, S.A., Lurie, B.D. (1964). Varieties and agricultural technology of peas. Leningrad: Kolos, p:360.

Kumari, N., Srivastava, J.P., Singh, B. (2009). Heritability and genetic advance in vegetable pea (Pisum sativum L.). Annals of Horticulture, 2:224-225.

Google Scholar

Makasheva, R.K., Drozd, A.M. (1987). Determinate growth habit (det) in peas: isolation, symbolization and linkage. Pisum Newslett, 19:31-32.

Google Scholar

Makasheva, R.Kh., Khangildin, V.V. (1990). Genetics of peas. Genetics of cultivated plants. Leningrad, p:15-80.

Makasheva, R.X. (1973). Peas. Leningrad: Kolos, p:312.

Makasheva, R.X. (1979). Peas. The cultural flora of the USSR. Cereal legumes. Leningrad: Kolos, 4:324.

Makasheva, R.X. (1975). The main morphological and biological features of peas. Genetics and selection of peas. Novosibirsk, p:3-36.

Makasheva, R.X. (1971). The species composition of the genus Pisum L. Works in applied botany, genetics and selection, 44:86-104.

Maxted, N., Kell, S., Toledo, A., Dulloo, E., Heywood, V., Hodgkin, T., Ford-Lloyd, B. (2010). A global approach to crop wild relative conservation: securing the gene pool for food and agriculture. Kew Bulletin, 65:561-576.

Google Scholar Crossref

Meunissier, A. (1922). Observations sur l'hérédité du caractère "Pois à trois cosses" et du caractère "Pois chenille". Genetica, 4:279-320.

Polunin, I.A., Litvinenko, M.V., Arshinov, V.I. (1977). Harvest and quality of green peas of brain varieties with different grain hardness. Works on the selection of vegetable crops. Moscow, 6:84-89.

Rasmusson, J. (1935). Studies on inheritance of guantitative characters in pisum. Hereditas 1 Preliminary note on the genetics of flowering, 20:161-180.

Rawal, V., Navarro, D.K. (2019). Dry pea: production driven by demand for animal feed. The Global Economy of Pulses. Rome, FAO, p:99-108.

Rowlands, D.G. (1964). Genetic control of flowering inpisum sativum L. Genetica, 35:75-94.

Google Scholar Crossref

Uvarov, V.N. (1993). Lupinoid-a new type of determinism in peas. Breeding and seed production, 5:19-20.

Uvarov, V.N. (1995). Some results of the study of a new form of peas with multiple apical peduncles. Genetics and plant breeding: Abstracts of the scientific conference of VNIIZBK. Orel, p:29.

Vasilenko, A.O., Derebizova, O.Yu., Timchuk, S.M. (2011). Dry matter and sugar content in technically ripe grain of different varieties of vegetable peas. Tavriya Scientific Bulletin: Agriculture, Crop Production, Vegetable Growing and Melon Growing, 77:37-42.

Vaughan, J.C., Geissler, C.A. (2009). The new Oxford book of food plants. New York: Oxford University Press, p:249.

Vozovik, I.S. (1983). Progressive technology for harvesting legumes. Kazan: Tatar book Publishing House, p:112.

Zelenov, A.N., Shelepina, N.V., Mamaev, M.V. (2013). Features of the amino acid composition of the protein of leaf pea mutants. Legumes and Cereals. Orel, 1:21-25.

Zelenov, A.N., Zotikov V.I., Shchetinin V.Yu. (2008). Prospects for the cultivation of non-traditional pea morphotypes. Feed production. Moscow, 3:27-29.

Zhukovsky, P.M. (1964). Cultivated plants and their relatives; 2nd ed., Revised and add. Leningrad: Kolos, p:791.

Citation:

Poltoretskyi, S., Karpenko, V., Liubych, V., Poltoretska, N., Bilonozhko, V., Demydas, H. (2022). Morphological and ecological features of green pea (Pisum sativum L.). *Ukrainian Journal of Ecology.* 12:12-19.