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BARLEY *(HORDIUM L)* USAGE, HISTORY, SYSTEMATICS, MORPHOLOGICAL FEATURES AND DEVELOPMENT PHASES

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Abstract. *In this thesis, the importance of the barley crop belonging to the group of spiked grain crops in the national economy, the centers of origin, the cultivated area in the world countries and Uzbekistan, the average productivity indicators and the total yield, as well as the systematics of this crop, the general morphobiological valuable economic signs and the duration of the development periods are analyzed.*

Keywords: *barley, food, cereal, fodder, productivity, cultivated area, systematics, morphology, development periods.*





USAGE

Barley is a valuable cereal used in the food industry and as a valuable feed for animals. Barley grains are obtained from barley grain – barley, and barley differing in nutritional value and good digestibility.

The value of a crop is estimated by its valuable biological qualities, like early maturity, which makes it possible to cultivate it in northern areas. The crop is tolerant to drought and salt, which makes it possible to use the crop in harsh environmental conditions.

Content of "crude protein" in grain fluctuates from 7 to 25%. The embryo contains 26-36% of protein, 8-14% – in the endosperm, and 7-10% – in the shells, and in the biomass in the phase of earing – 1.8-3.5%. The protein fraction is heterogeneous: albumin 7.5-28.8%, globulins 7-21.9%, hordeins 15.6-46.4%, glutelins 18-47.5%, non-protein nitrogenous substances 7.5-16.9%. The average content of amino acids in the total protein of barley grain is: lysine 3.35%, histidine 2.09, arginine 4.37, aspartic acid 27.35, proline 12.32, cystine 1.17, glycine 3.81, alanine 4.10, valine 4.97, methionine 2.57, isoleucine 3.61, leucine 6.53, tyrosine 2.52, phenylalanine 5.24.

The biological value of barley protein is low 51.2%, compared with oat – 83.4% and wheat – 59.9%. The carbohydrate content is 44 - 56%, the main part is starch. This contributes to the quality of the beer. In addition to starch, there are hemicellulose, cellulose, dextrins and pectin substances. The content of oil (lipids) is 2.70 - 3.30%. The grain also contains enzymes, vitamins – thiamine, riboflavin, nicotinic acid, carotene, and tocopherol.

The quality of the grain depends on the degree of flaking of the grain. Since barley has a filmy grain, it first separates the flower florets and partially the outer shells and germ, which leads to a decrease in the quality of the grain.

HISTORY

N.I.Vavilov and other scientists established the following centers of origin of barley:

1. Ethiopian (Abyssinian) – there are all the various forms of double-row awned, six-row barley and bare barley.

2. East Asian – (China, Korea, Japan and areas of Tibet), the barley of this region is stunted, has dense shortened ear, short or awnless spines. There are six-row awned and furcate barley.

3. Persian-Asiatic – the area of wild spontaneous barley, which has different forms on the color of the ear, the length of the spit, the density and the degree of fragility of the ear.

4. Mediterranean – (North Africa - Egypt, Tunisia, Algeria), Palestine, Syria – the grain is large, the forms are resistant to diseases, have an intense waxy coating, is used for food.

5. Central Asian – Tajikistan, Afghanistan, Uzbekistan – rainfed, heat-resistant, drought-resistant, unstable to diseases. This barley is mainly fodder.

6. European – Siberian – resistant to soil acidity, are used widely in brewing.

7. Novosvetsky – North and South America – barley is introduced to this region from other centers, is the “youngest” center of barley origin. In this region, barley is resistant to lodging, early maturing and resistant to smut and rust.

Centers of origin of barley

CENTER OF FORWARD ASIA

It includes mountainous Turkmenistan, Iran, the Caucasus, Asia Minor and the Arabian Peninsula. Tetraploid wheats, Iranian and Timofeev wheats, various types of rye, barley, and types of chickpeas, lentils, vetch, alfalfa, and sebarga are collected in this gene center.

MEDITERRANEAN CENTER

It includes Egypt, Syria, Palestine, Greece, and Italy. This center is an ancient genetic center of plant science. This center is durum wheat, monograin, bigrain, turgidum, polish, emmer, spelled wheat, barley, oat, grain-legume, lentil, ancient lupins, large-seeded flax, safflower, sugar and Khuraki is the homeland of beets, olives, grapes, laurel and other plants.

The beginning of the crop of barley is celebrated in the VIII-VII thousand BC in Front Asia, Iraq, in the Nile Valley, in southern Turkey. In England it is cultivated for 3400, in Denmark – 2650 years BC. In America, barley is a relatively new crop, cultivated since the sixteenth and eighteenth centuries AD.

Barley is a common crop, cultivated in many parts of the world. According to the FAO in 2019, the sown area, yield and gross production of barley are presented in Table 1.

Table 1.

Sown area, yield and barley grain production (FAO data for 2022)

Country	Sown area, 000 ha	Productivity, centner / ha	Gross production, 000 tons
In the world	**63,8**	**21.2**	**158,979,610 tons**
Argentina	1,256	40.7	5,117
Australia	4,436	19.8	8,818
Canada	2,727	38.1	10,382
China	2,600	34.6	9,000
Czech Republic	3,489	45.7	15,937
Kazakhstan	2,976	12.8	3,830
Mexico	2,969	20.0	59,443
Russia	8,536	6.7	2,400
Ukraine	3,233	23.3	75,616
United States	8,830	41.8	36,918
Uzbekistan	91.9	19.5	183,340

Systematics. Genus – *Hordeum* has two subgenuses: 1. *Hordeum*-large-seed barley, including cultivated and wild species, and 2. Hordeastrum-barley grasses, having small grains.

The first subgenus is divided into *H. vulgare L.* and *H. spontaneum C. Koch. H. Vulgare* – common barley has multi-row and double-row forms. Each of them has varieties that have membranous and bare grains.

Cultivated barley – annual plant, stem height is 70–90 cm and thickness is up to 3 mm, straight, hollow. Vaginas of leaves and plates are usually bare, rarely haired, the tongue is short, the ears are large, curved, that's why is very different from other grains. The inflorescence is the elbow, and the segments of the stem rod do not disintegrate when mature, and they are strong, straight, and long. On each ledge of the spike stem there are three spikelets with one flower, of which all three are fertile – multi-row barley or only one middle spikelet-barley is rowed. In

double-stranded barley side spikelets are fruitless. Each spikelet has two spikelet florets, narrow, up to 1 mm, less often wide – more than 1 mm, young with long or short hairs. There are two flowering florets; the outer florets are convex, five-nerve, passing into a serrated or smooth awn. Less often, awnings are absent and go into three-blade appendages – furcats. The inner floral florets are two-keeled, covered at the base with short or long hairs. The color of the films can be different – light yellow, brown, purple, gray, and black. The color of the ear and spines may vary in shades and intensity. The external and internal floral florets tend to grow together with the grain (membranous barley), less often they do not grow together (bare barley). The kernels are large, oblong, with a groove on the ventral side, of different colors — yellow, gray, green, purple, and black. The aleuronic layer in barley, unlike other cereals with one row of cells, consists of several rows of cells. Plants are self-pollinated, and diploid 2n = 14.

Varieties of cultivated multi-row barley – afganicum, anomalum, atratum, atricornutum, atrispicatum, atrum, chinense, dundar, nigripallidum, nigrum, pallidum, parallelum, pavonicum, piramidatum and others. 57 species are described in total. Varieties of multi-row barley are coeleste, acachicum, addisabebe, aethiopicum, amaricum and others. 57 species are described as well.

Varieties of cultivated double-rows barley are abyssinicum, africanum, asmaricum, braunii, breve, contractum, dubium, erectum, glabrispicatum, medicum, nigricans, persicum, rarum, rubrum and others. 64 types are described. Varieties of double rowing barley are nudum, colonicum, decorticatum, duplialbum, nigrinudum, viride and others. 38 species are described.

MORPHOLOGICAL FEATURES

Root. Barley has a fibrous root system, consisting of primary – embryonic and secondary – node roots. Embryonic roots begin to develop in the embryo grain, and secondary – later from the underground stem node. The roots absorb water and minerals from the soil and are involved in the metabolism of the whole plant. Depending on growing conditions, embryonic roots die off quickly or grow to the end of the growing season. Usually, under conditions of water deficiency, embryonic roots develop better and penetrate into the soil up to 1 m, and secondary roots do not develop in such conditions. In conditions of good water availability, secondary roots develop well. The primary and secondary roots are covered with numerous short root hairs, sucking water and minerals. Barley develops several embryonic roots. In two-row barley germ roots are more than multi-row. Scientists associate this with seed size. The growth and development of the roots goes on differently if the growing conditions are different. In conditions of dry area, there is a rapid growth of the roots to the heading. Under irrigation, the root and vegetative mass increases faster from heading to full maturity.

Tillering node and stem. Primary roots are separated from secondary by epicotyl – this is the lower part of the embryo that is transitional from stem to root. In case of small seed embedding, epicotyl is not pronounced. All shoots are covered with caps, called coleoptile. The coleoptile protects the first leaves of shoots during germination and breaks through the soil crust. The number of shoots depends on the variety, wintering conditions. The stem is a hollow straw, where nodes and internodes alternate. Resistant to lodging varieties in the lower part of the straw have a larger diameter, wide sclerenchymal ring.

All forms of barley have stems from 45 to 160 cm in height, but in the dry areas of Asian part of the world – 15 - 20 cm. The thickness of the stem of the world collection of barley varies

between 1.7 - 6.5 mm. In most varieties, the stem has 5 - 8 nodes. The upper internode is the longest and thinnest, which sometimes causes lodging of the whole plant.

Leaf. The leaf is located alternately on opposite sides of the stem, consists of the vagina and leaf blade. At the junction of the vagina in the leaf plate is a thin film (ligula) tongue adjacent to the stem and protects the stem from the penetration of water and pests between the stem and the vagina. The uvula has a color ranging from light green to violet, and the tongue is 2–5 mm long. At the base of the lamina, horn-shaped ears are formed, reaching each other's ends. The top leaf is flag, it hides the whole ear. The width and length of the leaves differ widely: the length is 8-25 cm, and the width is 4-32 mm. Green leaves are of different intensity. Leaves with respect to the stem are sometimes straight up, and sometimes drooping. The number of leaves is 4-7 pieces.

The features of the anatomical and morphological structure of the leaf are associated with biological properties – cold resistance, drought resistance, productivity, etc. When exposed to low temperature, the mesophyll and epidermis are destroyed. Drought-resistant forms have a small-cell structure, which is characteristic of xerophytes.

Spike. Inflorescence – spike, consisting of a crank stem and spikelets. Spike stem is flat, narrow or wide. Three single-flowered spikelets sit on the ledges of the segments of the hair shaft. The length of the segments of the ear stem is from 2 to 4 mm, so the ears are dense or loose. The density of the spike is determined by the number of segments of the spike stem per 4 cm of the spike length. In wild barley, the segments of the spike stem disintegrate upon maturation.

Spikelet florets are narrow, wide, haired or smooth and often awned. The outer floral florets always have 5 strings. The outer floral florets in the upper part transforms into a serrated or smooth awn. Furkat barley has appendages instead of spikes. Awns play a prominent role in grain filling, and participate in photosynthesis, in the metabolism of parts of the ear. The internal floral florets adjoin the spike stem, have a two keel shape, can be young, and always awnless. Lodicula has a different shape – rounded, trapezoid, leaf-shaped, and different lengths of hairs. If the lodicules are large, there is usually an open type of flowering, and cross-pollination. Barley has a closed flowering type, is a self-pollinator, but there is a lot of information about the open flowering type. Open flowering is observed mainly in small-seed barley. The size of pollen in most species is 34-45 mm.

Grain. Grain is fruit of cereals. Cultivated barley has a length of 7–10 mm, a thickness of 2–3 mm. The 1000 kernel weight is 31 - 52 g. There are new varieties having a weight of 60 - 65 g. The shape of the kernel is rhombic, elongated, and elliptical. The grain is scarious and naked. On the ventral side there is a groove of various depths and widths. The color of the grain in the bare barley is cream, blue, blue, green, brown, black and purple, and black. The main parts of the grain are: the fruit coat (pericarp), the seed coat (sperm), the endosperm and the embryo. Pericarp is formed from the walls of the ovary. The seed coat is folded from the shells of the ovules. Under the seed coat is the aleurone layer. Among the species diversity of barley, species with different thickness of the aleurone layer are described. In the central part of the endosperm are large starch grains. The embryo is located in the lower part of the dorsal side of the grain. It consists of a shield, a bud, closed in a coleoptile and an embryonic root. The number of roots depends on barley species and cultivation conditions. Large-seeded membranous barley in laboratory conditions retain germination for up to 10 years, annual wild-growing – up to 7 years, and the smallest-seeded – up to two years. The study of the species of barley according to this trait shows a great diversity of the rest period and the biological germination of seeds.

DEVELOPMENT PHASES

Shoots. The germination of barley seeds requires heat, water and oxygen. At optimal levels of these factors, shoots appear on the 5th - 7th day. If the heat is not enough, shoots appear on the 15th - 20th day. 48 - 65% of water is required for seed germination in relationship with the dry seeds weight. The germination of barley seeds can be observed at 1 - 3°C, but the optimum is 18 - 25°, and the maximum temperature is 28 - 30°C. Such factors as lack of water, low temperatures, compacted soil, formation of soil crust, excessive moisture, and a large embedment depth have a negative effect on seed germination.

Embryonic roots and germ sprout are formed in the germination period. Germ roots penetrate the soil, and the first leaf, protected by colorless coleoptile, rises to the soil surface. Shoots usually end with the formation of three leaves.

Tillering. With the formation of three leaves a noticeable stem node is formed at the surface of the earth. From this node, secondary, or node roots and additional shoots are formed. The number of shoots formed shows the degree of tillering. Under favorable conditions of cultivation, additional shoots are slightly late behind the main stem and contribute to higher yields. If the tillering is stretched, the shoots of late formation do not carry ears or they do not ripen. The number of shoots per plant can be from 1 to 16 stems, thus forming a bush of various shapes: erect, creeping and intermediate.

Stem elongation. This phase is associated with the expansion of internodes and the formation of a rudimentary spike. Usually, the beginning of the stem elongation begins 4 to 6 weeks after the emergence of shoots. Unfavorable conditions in this phase affect the formation of reproductive organs. The lack of water, nutrition, light will lead to sterility or a decrease in the number of grains.

Heading. The beginning of the phase is marked when 1/3 or 1/5 of the spike appears from the vagina of the upper leaf. In hot, dry weather, the ear may not appear from the leaf vagina. This was observed on rainfed conditions of Uzbekistan in 1980. The duration of the period of seedlings - earing varies in large intervals. It depends on the ecological and geographical conditions and varietal characteristics. On average, barley stands out faster in a long day than in the south in a short day.

Germination-earing period is highly susceptible to external environmental factors, especially temperature and ligh.

Flowering. Barley is a self-pollinating plant that flowers when the ear is in the vagina of the leaf and the flowering coincides with the earing. In conditions of heat or heavy rains, the flowers are not pollinated and there is empty every other grain, which in rainfed conditions amounted 10 - 15%. There are cases of open flowering and cross-pollination, and it is always associated with adverse weather conditions.

According to F.M. Kuperman, **the vegetation period** is divided into 7 stages of organogenesis.

Table 2

Stages of barley organogenesis

Stage	The degree of differentiation of organs	Phenological phases
I	Stem shoot is not differentiated, the cone of growth in the form of a node with a wide base is 0.25-0.5 mm	Emergence of shoots and tillering

II	The beginning of the differentiation of the growth cone with its slight expansion. Differentiation of rudimentary stem nodes, tightly located in the form of rollers at the soil surface.	Formation of tillering node
III	Elongation of the upper part and differentiation of the lower part of the cone of growth. Ridge stem nodes with internodes are detected. The beginning of the development of leaf rollers	Start of tillering
IV	The appearance of the ear humps is the beginning of the generative period	Complete tillering
V	The beginning of the formation of flowers in spikelets and the laying of spikelet floret.	Complete tillering
VI	Intensive formation of generative organs, clearly visible nodes, giving rise to the development of anthers and pistils.	Stem elongation
VII	Completion of the differentiation of all parts of the spike and individual flowers	Harvesting

Grain maturity. The process of grain maturity takes a long period. Grain formation begins 10 to 15 days after pollination. This period is called milky maturity, in which the grain is green and the humidity is 60-80%.

In waxy maturity, the plant acquires a yellowish color, and the grain is soft, cut with a fingernail. Grain moisture is 25 - 30%. In this phase of ripeness, an important biological process takes place – the grain is separated from the parent plant, the influx of plastic matter stops, the embryo stops growing. Grain acquires a new quality – germination. Waxy maturity can last from environmental conditions of 7 to 15 days. Then comes full maturity, when the grain becomes hard, has the shape, color, size characteristic of the sown variety. In this maturity, the harvest is required to be done urgently, as some varieties shattering down or fall for various reasons. The unfavorable weather during the grain filling period deteriorates all the grain quality indicators – sown, technological, quality and brewing.

The vegetation period is an important biological property, showing the genotypic characteristics of the variety and the environment. The amplitude of the growing season is 55 - 120 days.

The duration of the interphase period flowering-maturation depends on the temperature factor. With increasing temperature, the period is reduced.

REFERENCES

1. Atabaeva X.N., Khudaykulov J.B. Scientific basis of cereal crop biology. Textbook for masters. "Fan Ziyosi" publishing house, Tashkent-2022. Pages 123-131.
2. Atabaeva X.N., Khudaikulov J.B. Plant science. "Science and technology" publishing house, Tashkent - 2018. Textbook. 25.5 b.t. 407 p.
3. Atabaeva X.N., Khudaykulov J.B., Nurbekov A.I., Kassam A. Plant Science. Textbook (in English). "Science and technology" publishing house, Tashkent - 2021. Textbook. 25.0 b.t. 398 pages.

4. Усаров З.И., Маматқулов Т., Покровская М.Н.. Суғориладиган майдонларда “обикор”арпа навини етиштириш технологияси. Том 2 № 13 (2022): Eurasian Journal of Medical and Natural Sciences *(https://in-academy.uz/index. php/EJMNS/article/view/6973).*
5. Маматқулов Т., Холдоров А.А., Усаров З.И., Хусанов О.Н. Лалмикор майдонларда арпа етиштириш бўйича тавсиялар. Тафаккур нашриёти, Тошкент-2020, 7 бет.
6. FAO statis.data base 2022 year.
7. Ўзбекистон Республикаси ҳудудида экиш учун тавсия этилган қишлоқ хўжалик экинлари Давлат реестри. Тошкент - 2022 йил.