Agronomy – Rabi Crops

Barley

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BARLEY

Botanical Name: *Hordeum vulgare* L.

Chromosome number: 2n=14

Barley is the fourth most important cereals of the world after wheat, rice and maize. It is a major source of food for large population of cool and semi-arid areas of the world, where wheat and other cereals are less adapted. In European countries, it is used as the only breakfast food, whereas the people of Nepal, Tibet and Bhutan use it as a staple food. The most important uses of barley in India include green feed to livestock and poultry, as malt for manufacture of beer and other liquors like brandy, whisky etc. Sometimes barley is mixed with wheat or gram and then ground to flour for preparing better quality *chapaties*. Grains are roasted and ground to use it as *sattu*. Barley is used for manufacturing of liquors in western countries.

Origin and History

Barley has probably originated from Asia and Ethiopia with centres of diversity i.e. north-east Africa and Mountainous regions of Abyssinia (occidental types) and south-east Asia, China, Japan, adjoining regions of Tibet (oriental types).

Occidental types are characterized by broad empty glumes, 2 row with empty spikelets, pubescent palea and coloured stem. Oriental types are characterized by naked or hooded barley with resistance to some races of mildew and possess extreme earliness or lateness. The two rowed *Hordeum spontaneum* K. Koch barley is believed to be the wild progenitor of domesticated or cultivated barley.

Barley must have been introduced to India soon after the arrival of the Aryans. Its Sanskrit name ‘Yav’ is mentioned in ‘Ved’, and use of barley in religious ceremonies has been described, which shows that it was grown in India since ancient time.

Geographic Distribution

Barley is one of the major cereals of the world cultivated over 57.62 million ha with a total production of 154 million tonnes in 2004. Russia, China, France, Canada, USA and Spain are the main producers of barley. The area (million ha), production (million tonnes) and productivity of barley in major countries are given in Table 1.

Table 1. Area, production and productivity of barley in major producing countries of the world

Country	Area (m ha)	Production (m t)	Productivity (kg/ha)
Russian Federation	9.05	17.18	1797
Canada	4.05	13.19	3256
Germany	1.98	12.99	6564
Ukraine	4.51	11.08	2455
France	1.63	11.03	6764
Spain	3.09	10.61	3434
Turkey	3.60	9.00	2500
Australia	4.61	7.71	1669
USA	1.63	6.09	3743
UK	1.01	5.82	5757
Poland	1.01	3.57	3521
China	0.79	3.22	4099
Morocco	2.32	2.76	1187
Iran	1.40	2.00	1429
India	0.75	1.37	1827
World	**57.62**	**154.14**	**2675**

Source: *FAO Production Year Book, 2004*

Barley is also an important cereal in India. The chief barley-growing regions in the country are Himalayas, Central part of eastern Uttar Pradesh, eastern parts of Rajasthan and north-western part of north Bihar. In India barley is cultivated on about 0.75 million ha with a total production of 1.37 million tonnes. The area, production and productivity of barley in major states of India are given in Table 2.

Table 2.Area, production and productivity of barley in important states of India (2004-05)

State	Area (000 ha)	Production (000 t)	Productivity (kg/ha)
Bihar	17.3	18.3	1058
Chattisgarh	3.8	3.2	842
Haryana	25.0	67.0	2680
Himachal Pradesh	24.0	42.0	1750
Jammu & Kashmir	11.0	10.0	909
Jharkhand	12.9	11.7	907
Madhya Pradesh	83.2	104.1	1251
Maharashtra	4.3	1.7	395
Punjab	22.0	74.0	3364
Rajasthan	175.5	417.7	2380
Uttarakhand	24.0	33.0	1375
Uttar Pradesh	205.4	411.7	2004
West Bengal	2.4	4.0	1667
India	616.5	1207.1	1958

Source: Fertilizer Association of India, 2006

Classification

The genus *Hordeum* has about 350 species, of which 32 are wild and cultivated. These 32 species are divided into 2 groups.

Hordeum sensu stricto: It has 2 species viz. *H. vulgare* L. and *H. bulbosum* L. The wild and cultivated forms of barley belong to *H. vulgare* ssp. *spontaneum* and *H. vulgare* ssp. *vulgare* respectively.

Hordeum cristesion: The remaining species of barley falls into this group.

Based on fertility status and arrangement of 3 spikelets on rachis, barley is classified into 3 types.

Two row barley *(Hordeum vulgare var. distichon):* In this, the central spikelets are fertile, while lateral spikelets are sterile. Thus when spike is viewed from top or bottom, the spikelet arrangement appears to be in two columns. Each spike produces 15-30 kernels.

Six row barley (*Hordeum vulgare* var. *hexastichon*): In this, all 3 spikelets are fertile and each spike produces 25-60 kernels.

Irregular barley (*Hordeum irregulare* L.): In this, the central spikelets are fertile with some fertile and sterile lateral florets.

On the basis of presence or absence of seed cover, both 2 and 6-row barley have been sub-divided into 3 varieties.

Var. *nudum*: called naked barleys, in which caryopsis becomes hull free after threshing. Also called hull-less types. These are useful for human consumption.

Var. *trifurcatum*: called hooded barleys, in which the inflorescence has a modified lemma awn that resembles a hood over florets. Hoods may have both male and female organs and in rare instances produce viable seed. Also called hulled (husked) barley. They are important for livestock feeding and malting.

Var. *inerme*: These are called awnless barley.

Botanical Description

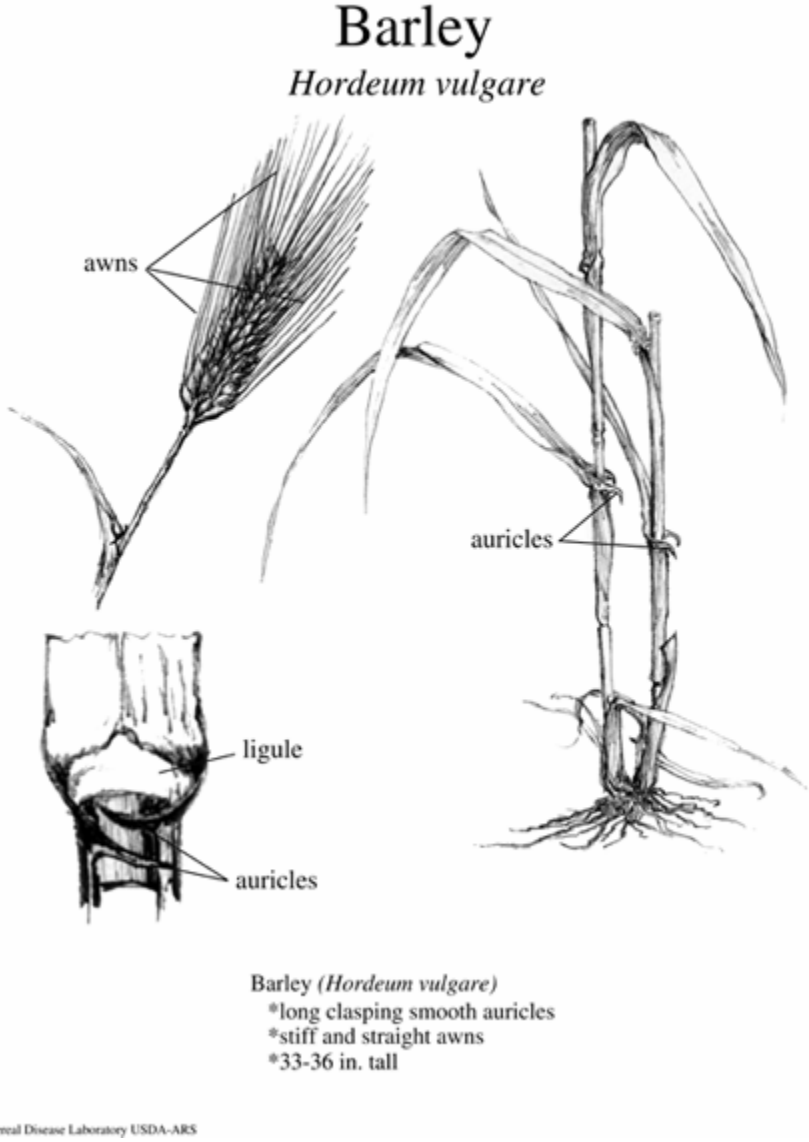
Barley has all the vegetative characters like wheat; except that the auricles of leaf are conspicuous and very much pronounced which clasp the culm. The botanical description of main parts is given below:

Root

Barley possesses of shallow and deep roots. The shallow roots emerge near the soil surface and spread out laterally apart 15-30 cm almost at the right angles for the tillers; whereas deep roots extend downwards into deep layers of soil. The depth of penetration varies from 75-150 cm.

Stem (culm)

The cylindrical stem possesses 5-7 hollow internodes separated by solid nodes where from the leaves arise. Internodes are short at the base of the plant, and their length increases from the base of the stem to upwards. The usual number of tiller/plant varies from 2 to 5.



Leaves

The leaf blade is hairy or slightly serrated having light green colour compared to wheat. Each leaf consists of a sheath, blade, ligule and auricle. The leaves of

barley are usually broader and of the lighter green colour than wheat. The leaf sheath is generally glabrous, but in a few cultivars it is covered with hair. They possess small ligule (0.5-3.0 mm). Auricles are very conspicuous, which partly or entirely clasp the stem and much longer than those in wheat. Two-row barleys have narrower leaves than 6 row barleys.

Inflorescence

The inflorescence is also known as spike or head. The spike at the top of the culm consists of spikelets attached at the nodes of a zig-zag rachis. Each spikelet has 2 glumes and a floret. The barley flower has 3 stamens and a pistil with a single ovule and a stigma. Barley is a normally self-pollinated crop.

Kernel (grain)

Barley grain is a ‘caryopsis’ consisting of lemma, palea and a rachilla. The caryopsis is composed of the pericarp, endosperms and embryo. Barley grain is a caryopsis measuring about 8-12 mm long, 3-4 mm wide and 2-3 mm thick. The grains normally consist of hull except that of naked cultivar which becomes free after threshing. Spikelets may be awnless or hooded, awned or beared all these species of barley are under cultivation.

Growth stages of barley

Barley has six well defined growth stages as detailed below.

1. **Germination and seedling stage**

   This stage starts from seeding to 20-25 days after sowing (DAS). With germination, the coleoptile emerges out of soil producing leaves. This stage ends with the exhaustion of endosperm and crown root initiation.

2. **Tillering**

   This phase lasts up to 30-35 DAS during which, tillers emerge from the crown and grow along with the main stem. Tillering is more in 2 row than 6 row barley.

3. **Jointing**

   This is also called shooting stage and lasts up to 55-65 DAS. The stem becomes visible, nodes multiply and internodal distance becomes longer. Flag leaf (the last leaf covering ear), emerges. The lower leaves starts withering while younger leaves continue to emerge and grow.

4. **Heading (earing stage)**

   The ear emerges from flag leaf and anthesis of central floret begins. This stage lasts up to 75-85 DAS and ends with production of watery grains.

5. **Ripening**

   This stage lasts up to 90-100 DAS and involves post milking, grain filling and development. The grains gradually become hard.

6. **Maturity**

   The grains loose moisture and plant parts get dried in the phase.

Climate

Barley is a crop of cool climate, and can also be grown successfully in tropical and sub-tropical regions. As in wheat, barley has also both winter and spring types. Winter types require vernalization (exposure for low temperatures <50^{o}F for 2-10 weeks) for completion of life cycle. In India, it is basically a winter crop. However, at higher elevations as in Ladakh and Lahaul, its spring cultivation also does exist. It is grown from near sea level to an elevation up to 4500 m. Barley performs best in areas of relatively high rainfall, low relative humidity and cool temperatures at maturity. A mean daily temperature of 12-15^{o}C and 30^{o}C during growth and ripening phases respectively are best for barley cultivation. It is grown under rainfed, drought prone conditions and in regions where wheat cultivation is uneconomical. A well distributed 200-250 mm rainfall can support barley crop, however, the crop does best with 400-500 mm annual rainfall. Barley being a long day plant would prefer a photoperiod of 10-12 and 12-14 hours during vegetative and reproductive stages, respectively.

Cropping Systems

Barley, owing to its drought resistance and short duration finds place in several sequential and intercropping systems. In crop rotations, it follows *kharif* cereals (rice, maize, pearlmillet, sorghum), legumes (pigeonpea, cowpea, groundnut) and commercial crops (cotton, potato, sugarcane). Under adequate, irrigation, short duration pulse or fodder succeeds barley. In *diara* lands of eastern Uttar Pradesh, vegetable-barley sequence is followed.

Under rainfed conditions, inter or mixed cropping of barley with pea, rajmash, linseed is extensively followed.

Soil and its Preparation

Barley thrives well on well-drained, medium fertile, deep-loam soils with neutral to mild salinity (7-8 pH). Highly fertile soils are not conducive for barley cultivation. Being salt tolerant, it is the best option in sodic soils. Its cultivation has become possible on saline coastal areas of Sunder ban in West Bengal and saline black soils of canal irrigated areas of northern Karnataka. Acidic soils are not suitable for barley cultivation, and liming is must in these soils for better yields. The soil should not be very fertile as the crop lodges very severely and drastic yield loss is observed. It is susceptible to waterlogging.

Barley being a shallow-rooted crop responds well to light-textured fine seed-bed. The desired tilth may be obtained by one ploughing with soil turning plough followed by 2-3 harrowings. The planking should follow every ploughing or harrowing as it pulverizes soil and also conserve moisture. In dryland areas, the rain water should be conserved by deep summer ploughing, discing after every rainfall and levelling and field bunding during monsoon. This conserved moisture may be fully utilized by an early sowing of barley crop. The roots and stubbles of previous crop and the weeds should be picked up and thrown out of the field as they attract termites. Before last ploughing, 10-15 kg of 5% aldrin dust should be applied and mixed well with soil to protect the crop from termites. In saline soils, the land should be prepared and left undisturbed for a week's time before sowing. This aids in upward movement and accumulation of soluble salts from root zone. Seeding is done deep in less salty zone for better germination.

Varieties

A large number of varieties (~95) have been developed for cultivation in different zones. Naked barley, though suitable for both hilly and plains are mainly grown in hills for food as well as local brewing. The important varieties and their suitability for different purposes are given in Table 3.

Barley varieties for different states

State	Varieties released prior to 1980	Varieties released after 1980
Uttar Pradesh and Uttarakhand	C251[a], C84[1], C50[1], NP100 (For High Hills)*, Barley local* (For low hills), CN 292, C 294, K 12[1], Ballia Barley[1], C-138, K14[1], K18, K19[1], K24, K70, Kailash, Amber*[a], Vijaya*[2] (Western U.P.), LSB2[1], Ratna[1], Dolma, Azad (K125)*, Kedar (DL36)[1], HBL 113[a]	K-141*, Lakhan (K226)*, Jagarati (K287), BHS46*, VLB1, Manjula (K329)[1], BHS-169*, Geetanjali (K1149)*, K409[1], Karan 16, , RD2508[1], Pragati (K508)[1,c]. Haritma (Eastern UP), NB1 (NDB 209)[1], NB2 (NDB940)[1], NB3 (NDCB 1020)[1,c]
Punjab and Haryana	T4[1*,ab,] T_5[2,ab], NP 104, C138*, C144*[a], C155[2,ab], C164, Clipper[2,a], Jyoti, Himani, Ranjit, BG25[1], BG105[1], PL56*[1]	BH75, PL-172, Karan 16, RD 2035[1], Alfa 93, PL 419[*,1], PL 426[1], Karan 16, BH 393[1]
Rajasthan	NP-13, NP 103[2], RS-17, RDB1, RS6 (Central plains)*[,ac], RD31*[1], RD57[1] (for low fertility soils), RD103[1] (for high fertility soils), Bilara-2 (Saline and alkali soils)[1]	RD 2052[1], Alfa 93[2,ab], RD 2592[1]

State	Varieties released prior to 1980	Varieties released after 1980
Bihar	NP-13, NP 103, BR 21, BR 22*, BR 31, BR 32, Ratna, Azad , Kedar	Haritma (K 560)[1]
Tamil Nadu	NP 106 (For Nilgiris)	
Himachal Pradesh	KB 71, Kailash, LSB 2, Himani, Dolma[1]	Sonu (HBL 87)*, BHS 46*, BHS-169, HBL 113[2], HBL 316*[1]
West Bengal	Kedar, Azad	Ritambhara, Haritma
All zones		Rekha (BCU 73)[2]
North West Plains Zone	RD 2552, DWR28[2,ab,]RD2503[1,a], RD2624*,[1], NDB1173 (Saline soils), DWR 46[2,ab], DL88[1,a+,] DWRUP 52[a, I], RD 2668[a, 1,]	
Plains Zone	RD 2552, DL 88[1], Pl 751[c, 2]	
North East Plains Zone	K 603*[1], NDB 1173 (Saline soils), KT 13 [c,1], Ritambhara (K551)[a]	
Northern Hills Zone	HBL 276, BHS 352[*1]	

[a:] malting; [b]:brewing; [c]:feed; * Rainfed; [1]:6 row, hulled; [2]:2 row barley

Seed Rate, Spacing and Depth of sowing

***Seed rate*:** Seed rate varies according to agro-conditions. In irrigated areas for normal sowing, 75-90 kg of seed/ha is sufficient, while in late-sown conditions the seed rate should be increased to 90-100 kg/ha. Under rainfed conditions, 80-100 kg seed/ha is required depending on soil moisture availability. For saline and alkaline soils, use 100-120 kg seed/ha to ensure desired plant population.

Before sowing, the barley seed should be treated with vitavax, thiram @3 g/kg of seed to protect the crop from fungal diseases. For sowing in saline and alkaline areas, soak the seed in water over night at room temperature for better and quick germination.

***Spacing*:** The spacing between rows is usually 22-23 cm under irrigated and 23-28 cm under rainfed conditions. In saline and alkali soils, 20 cm row spacing is recommended. *Depth of sowing:* The best depth of sowing is 3-5 cm under irrigated and 5-8 cm under the rainfed conditions, depending upon the initial soil moisture. In clay soils or soils that have tendency to crust, shallow planting is preferable.

Method of Sowing

Method of sowing is an important aspect, particularly under rainfed conditions. Seed should be dropped with the help of *Nai* or *Pora* attached to country plough, or with the help of seed drill to ensure uniform distribution of seed at the optimum depth. In irrigated areas seed may be sown by '*Kera*' method, where seed is dropped by hand into the furrows. There should be adequate moisture in soil for proper germination.

Sowing Time

The normal sowing season extends from the middle of October to the middle of November. Under rainfed conditions, sowing should be completed during the third or fourth week of October. Delayed sowing reduces the yield per unit area and produce grain not fit for malting. Under irrigated conditions, first to third week of November is ideal for sowing.

At higher elevation (2,300 m), barley is grown as an irrigated spring crop with sowings extending from April to the end of May, depending on the time of melting of snow from the fields, suitable soil temperature to ensure good germination and the availability of irrigation water. On the Nilgiri Hills (Tamil Nadu), barley is sown in May-June or August-October depending upon the altitude and the pattern of rainfall.

Manure and Fertilizers

The rainfed crops are seldom manured directly. It is the preceding crop in the rotation which receives the manure. In irrigated crop, about 10-15 tonnes of FYM or compost should be applied about a month before sowing. The application of organic matter to soil besides providing essential nutrients to the crop also helps in overcoming salt problems of saline and alkali soils and moisture conservation.

Under rainfed conditions, 30-40 kg N/ha along with 20 kg P_2O_5/ha should be applied at the time of sowing. Irrigated barley is fertilized with 60 to 80:30 kg/ha of N:P_2O_5. Entire P along with $^1/_3$ N is applied are placed behind the seed. Remaining N is top dressed as urea in 2 equal splits after first irrigation and at flowering stages. Potassium fertilization is done based on soil fertility. Salt affected soils and hull-less varieties require more N fertilizer (80 kg/ha) than irrigated and hulled crop.

In malt barley, balanced fertilization with 40:25:25 kg/ha of N:P_2O_5:K_2O at the time of sowing is essential to maintain protein content. No top dressing of N should be done, as it enhances protein content.

Water Management

Barley is a drought tolerant winter season crop and thus requires less irrigation. However, the dwarf fertilizer responsive cultivars do require irrigation. In 2002-03, 62.2% of the total barley area of country was under irrigation. Besides a pre-sowing irrigation for crop establishment, the crop also requires irrigation at 3 critical stages *viz*. active tillering (30-35 DAS), flag leaf (60-65 DAS) and milking stages (80-85 DAS). Under limited water resources, i.e. available for one irrigation only, it should be applied at active tillering stage. If water is available for two irrigations, crop should be irrigated at active tillering and flowering stages. In saline soils, frequent irrigations are given to dilute the impact of salts. Heavy irrigation in March should be avoided to prevent lodging. Hull-less barleys with 10-15 days longer duration than hulled varieties require one additional irrigation at grain filling stage for proper grain filling and to overcome hot winds damage. This holds true for malt barley also as this crop should not suffer from moisture stress at any stage.

Fodder barley requires irrigation and top dressing of N immediately after first cut (60-65 DAS).

Weed control

The crop has early vigorous growth and by active tillering stage, it completely covers the soil resulting in smothering of weeds. Irrigated barley with high fertilization usually suffers from severe weed competition. The major weeds are *Anagallis arvensis* (*Krishna neel*), *Avena fatua* (wild oat), *Chenopodium album* (*bathua*), *Cirsium arvense* (*kateli*), *Melilotus alba* and *Melilotus indica* (*senji*). Weeds usually pose greater problem in irrigated areas.

The use of weed-free seed and thoroughly prepared seed-bed are essential for controlling the weeds effectively. One hoeing or hand weeding immediately after first irrigation takes care of weeds in barley. For control of broad-leaved weeds, application of 2,4-D sodium salt (80%) amine salt (72%) at 0.75 kg/ha + 3% urea solution in 700-800 litres of water at 30-50 days after sowing the crop is recommended. Under rainfed condition, slightly lower dose of herbicide i.e., 0.5 kg/ha is recommended. Isoproturon or methabenzthiazuron or metaxuron @ 1.5 kg/ha (post-emergence) have been found effective to control grasses.

Cropping systems

Owing to drought resistance and short duration, barley find place in several inter and sequential cropping systems. Under rainfed conditions, barley is inter or mixed cropped with pea, rajmash, chickpea, linseed etc. In crop rotations, it follows *kharif* cereals (rice, maize, pearlmillet, jowar), legumes (pigeonpea, cowpea, groundnut) and commercial crops (cotton, potato, sugarcane). In diara lands of eastern Uttar Pradesh, vegetable-barley rotation is followed. Under adequate irrigation, short duration pulse or fodder succeeds barley.

Harvesting and Threshing

The crop is harvested by cutting at the ground level when the plants dry up, grains become hard and stem breaks down with slight touch. Delayed harvesting results in lodging and shattering of grains. The harvested crop is bundled and placed in threshing yard and allowed to dry. The dried crop is threshed either by trampling by bullocks or mechanical threshers. The produce is winnowed to clear chaff and unwanted materials. The straw serves as important feeding material for livestock. In recent times, combines are used to do all the 3 operations in a single step.

Yield:

Barley yields 3-5 t/ha of grain and equal amount of straw depending on variety and management.