Barley *(Hordeum vulgare L.)*

French: Orge, escourgeon (winter barley); Spanish: Cebada; Italian: Orzo; German: Gerste

Crop data

Annual, winter- and spring-sown types; ears 2- or multiple-rowed; grains generally with glumes.

Harvested products: grain, straw, (occasionally) whole green plant.

Desired characteristics affecting fertilizer requirement:

In grain for livestock feed: high crude protein, especially lysine. In grain for processing for use in human foodstuffs: high-protein endosperm, lack of excrescences, low husk content.
In grain for malting: high starch, low crude protein, lack of excrescences.

Straw for bedding: should be dry, absorbent material.

Whole green plant for forage: high crude protein and energy, smooth glumes.

Sowing times: winter varieties should have completed tillering before the vegetative rest period, i.e. normally within 45 days (of real growth) from emergence. On the other hand, excessive early development of biomass is undesirable as it reduces winter hardiness.
Spring varieties should be sown as early as practicable, when temperature, moisture and other soil conditions permit.

Plant density: sowing rates for 2-rowed types are within the range of 320 - 365 grains/m^2 (at a desired optimum ear density of 700 - 800 ears/m^2). With multiple-rowed winter barley the following model calculation may serve as a guide:

Expected yield = 9 t/ha; required ear density = 600 ears/m^2. With an estimated germination rate of 95 %, an overwintering rate of 85 % and 2.7 ears per plant, the seeding rate should be 280 grains/m^2 (see also 2.3 Wheat).

Temperature limitations and the duration of the various growth phases are illustrated in the following table

Growth stages and climatic limitations in the development of barley							
Development stage	**EC[1)]**	**Duration (days)**		**Temperature (°C)**			**Minimum water demand (mm)**
		Winter barley	**Spring barley**	**min.**	**Opt.**	**max.**	
Sowing and germination	0.1-0.9	7	7	2-4	20-25	27	
Seedling emergence and early growth	1.0-1.9	5	11				
Tillering, initiation of ear primordia	2.0-2.9	60[2)]	10		< 8		32
Beginning of stem elon gation and formation of ear primordia	3.0-3.9	17	19		< 9		52
Flag leaf, floret reduction, booting	4.0-4.9	14	14		< 14		
Ear emergence	5.0-5.9	16	24				70
Flowering and grain initiation	6.0-6.9	12	5		< 17		22
Grain formation	7.0-7.9	15	25		< 19		74
Maturing of the grain	8.0-9.2	19	21		19		
Total		165[2)]	136	1 700 - 2 100[3)]			
1) EC = Eucarpia Scale; 2) To be added: duration of vegetative rest (depending on location, e.g.: 120 days); 3) Total daily temperatures above 0° C (temperatures below 0° C deducted).							
Source: Aigner et al., 1988; modified							

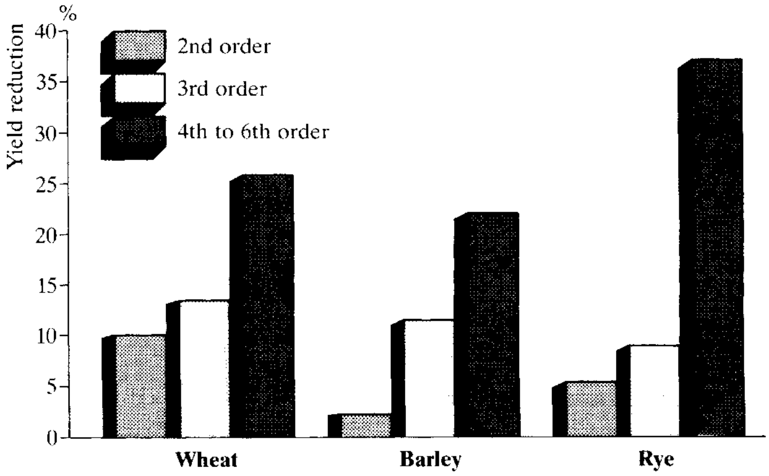
Yield structure: The next table shows the (relative) changes of yield components in correlation to varying amounts of plant available water; assuming that water supply is the primary yield-determining factor in cereals:

Yield structure of barley as function of plant available precipitation*							
Winter barley	**Plant available precipitation**						
	150 mm	**250 mm**	**350 mm**	**450 mm**	**550 mm**	**650 mm**	**750 mm**
Grain yield	15	32	62	85	100 = 6.8 t/ha	113	119
Ear density	33	57	70	83	100 = 600/m2	117	125
Single ear weight	44	57	88	103	100 = 1.13 g	97	96
Optimal number of ears per plant = 2.5 - 3.5							
Spring barley	**Plant available precipitation**						
	100 mm	**150 mm**	**250 mm**	**350 mm**	**450 mm**	**550 mm**	**650 mm**
Grain yield	23	33	51	86	100 = 4.8 t/ha	112	116
Ear density	37	50	77	88	100 = 670/m2	112	125
Single ear weight	63	65	66	97	100 = 0.72 g	100	93
Optimal number of ears per plant = 2 - 3							
Relative to 550 mm plant available precipitation for winter barley, or to 450 mm for spring barley Plant available precipitation = amount solely available for crop growth, i.e. excluding evaporation, runoff, drainage and other losses.							
Source: Heyland, 1961							

The grain yield of barley is related to the amount of water consumption, which increases over-proportionally with increasing yield; the same is true of N uptake. If maximum utilization of water and applied nutrients is required for optimum grain yield, then the ratio of the number of plants per unit area to the number of ears per plant must be optimized; thus the crop should tiller heavily. This can be influenced, depending on water and N supply, by application of N. Depending on the quantity and timing of N application, around 250 l water per kg grain yield may be needed, the coefficient of productive tillering (ear-bearing tillers / total tillers) ranging between 0.39 and 0.60.

As shown in the figure it is not so important in barley as in wheat to control the uniformity of different orders of tillers. Unproductive tillering (caused for example by a too high or too late N fertilization in spring) should, however, be avoided.

Yield reduction of the ear of a single tiller as a function of tiller position
(Tiller of first order = 100%)
Source: adapted from Brouwer, 1971



Two-rowed barley varieties have lower ear weights, consequently a higher ear density than with multiple-rowed types is necessary to reach the same yield. Higher seeding rates and productive tillering promoted by N-fertilizer use are therefore necessary with two-rowed types (e.g. 700 - 800 ears/m^2 as compared to 550 - 600 ears/m^2 on fertile soils with ample water supply). With multiple-row types the target should be about three ears per plant, and with spring-sown two-row types two ears per plant. Because of the importance of floret reduction and grain formation in two-row types, an adequate nutrient supply must be ensured during shooting and after flowering.

When the crop is grown for malting, a variety should be selected which is appropriate to the expected wheather conditions.

If the crop is undersown, the undersown crop should not be grown so early that it might outgrow the barley and reduce resistance to lodging.

Nutrient demand/uptake/removal

Relative nutrient uptake of barley in relation to plant development									
(max. = 100)		Winter barley				Spring barley			
Stage	EC*	N	P2O5	K2O	Dry matter	N	P2O5	K2O	Dry matter
		per cent of maximum							
Early growth	1.0-1.9	0	0	0	1	0	0	0	1
Tillering	2.0-2.9	27	20	24	10**	25	18	24	6
Jointing	3.0-3.9	42	29	33	9**	37	27	36	11
Booting	4.0-4.9	59	45	51	13	53	42	62	19
Ear emergence	5.0-5.9	82	71	88	53	77	70	97	47
Flowering	6.0-6.9	100	88	100	79	100	91	100	71
Grain formation	7.0-7.9	97	100	79	100	100	100	97	100
Physiological maturity	8.0-9.2								
- total plant		97	100	76	91	96	97	88	87
- grain only		63	86	28	62	71	79	29	53
Maximum		kg/ha							
- in total dry matter		119	51	217	11 000	102	33	139	9 000
- in grain only		75	44	60	6 800	72	26	40	4 800
* EC = Eucarpia Scale ** Decrease due to loss of biomass during winter									
Source: various sources and own experimental results									

Nutrient uptake/removal - Macronutrients				
Type of barley	Yield base t/ha	kg/ha		
		N	P2O5	K2O
Winter barley	Total dry matter: 11 Grain only: 6.8	119 75	51 44	217 60
Spring barley	Total dry matter: 9 Grain only: 4.8	102 72	33 26	139 40
Source: adapted from Heyland, 1961				

Fertilizer recommendations

The same principles apply as for wheat, but the exact timing of split applications of N is more critical, especially for winter barley.

Since the root system of barley is less readily established than that of wheat, attempts have been made (in the UK) to promote longitudinal root growth by autumn application of clormequat chloride to young plants; but the efficacy of this method has not yet been fully confirmed.

Owing to the greater tendency of barley to lodge, as compared with wheat, stem stabilizers are being used in intensive growing systems. As chlormequat by itself does not give sufficient reduction in stem length, a combination of chlormequat chloride and etephon is favoured, with etephon alone being used for late applications.

Preferred forms of fertilizer nutrients

N - Quick acting forms are preferred for malting barley; forms releasing N too late in the growing period should be avoided in order to minimize the risk of too high a crude protein content in the grain. Slurry in particular can cause serious problems; if used at all for malting barley, only small amounts should be applied. Too late application of N fertilizer should be avoided.

P - a good supply is especially important for malting barley.

K - potassium chloride. As for P, adequate K should always be available. In general, K increases lodging-resistance and frost-hardiness.

Mg - barley reacts intensively to deficiency, producing leaf chlorosis; even though this may not always significantly reduce yield, it should be corrected by application of adequate Mg-containing fertilizers.

For further details refer to 'Fertilizer recommendations' and 'Calculation of nutrient rates' for 2.3 Wheat.

Generally, for the application of P and K three methods are practised:
- application in autumn on the stubble of the preceding crop, or with autumn ploughing;
- application in spring (in form of a NPK complex fertilizer) with the first N;
- for barley following sugarbeet or maize in the crop rotation, P and K are given to the preceding crop, the barley receiving only N.

On soils with satisfactory reserves of P and K, the applied nutrient rates depend on the expected grain yield.

	Winter barley (yield expectation 7 t/ha grain)	**Spring barley (yield expectation 6 t/ha grain)**
N	100 kg/ha N* + 40 kg/ha N as late topdressing	80 kg/ha N** 40 kg/ha N as late topdressing
P	120 kg/ha P2O5	100 kg/ha P2O5
K	120 kg/ha K2O	100 kg/ha K2O
* Timing and splitting as for winter wheat ** For malting barley: 40 - 50 kg/ha N, no N topdressing.		

Fertilizer practice in other countries

Canada

Most barley produced in Canada is spring seeded. It is grown both for feed and malting purposes, with small amounts used for human consumption.

Fertilizer recommendations vary from region to region, depending on environmental conditions. Soil testing is recommended for specific fertilizer recommendations.

In drier areas, band application of N is generally recommended. Limited amounts of N may be placed with the seeds. In the moister areas, spring broadcast and incorporated fertilizer applications are quite efficient. In all areas P should be seed-placed or banded with N. K is also more efficiently used if banded than if broadcast. Limited amounts (less than approx. 35 kg/ha K2O) can be placed with the seeds.

Alberta

Crop - Soil zone	kg/ha					
	N		**P2O5**		**K2O**	**S**
	Stubble	Fallow	Stubble	Fallow		
Feed barley						
- Brown	22- 62	5-22	0-28	17-40	-	-
- Dark Brown	40- 73	5-17	0-28	17-40	-	
- Thin Black	40- 90	5-34	17-40	17-40	-	
- Black & Grey Wodded	45-112	5-45	17-50	17-45	(*)	0-30**
Malting barley						
- Brown	-	-	-	-	-	-
- Dark Brown	28- 56	5-17	0-28	17-40	-	-
- Thin Black	40- 73	5-28	17-40	17-40	-	-
- Black & Grey Wooded	34- 90	5-40	17-45	17-45	(*)	0-30**

* Potassium or chloride may be required on some sandy, calcareous soils and soils with poor subsurface drainage adjacent to and on organic soils.
** Sulphur deficiency may occur on some wooded soils.

Manitoba

Barley following	kg/ha			
	N	**P2O5**	**K2O**	**S**
Fallow or legume	0- 30	30-45	(15-35)*	(15)**
Grass or grass-legume	30- 60	30-45	(15-35)*	(15)
Cereal	60-100	30-45	(15-35)*	(15)

* On sands, sandy loams and organic soils only
** When required, as sulphate

Sasketchewan

Soil zone	kg/ha				
	N		**P2O5**	**K2O**	**S**
	Stubble	**Fallow**			
Brown	15- 45	0-10	20-30	-	-
Dark Brown	20- 65	0-15	20-40	-	-
Black	50- 95	15-60	20-40	-	-
Dark Grey	55-100	20-65	20-40	0-40	0-20
Grey	55-105	20-65	20-40	0-40	10-20
Irrigated	75-120	50-80	20-40	-	-

India

- irrigated:
  60 kg/ha N, 30 kg/ha P2O5
  Half of the N and all P before or at sowing, the remaining N topdressed at the first irrigation.

- rainfed: 30 kg/ha N, 20 kg/ha P2O5
  All N and P before or at sowing.

P should be placed 5 cm below the seed; application rates are adjusted according to soil test results.

Further reading

COMMONWEALTH AGRICULTURAL BUREAU: Barley: soil, water and nutrient relations (1974-1966). CAB Annotated Bibliography No. 1718 (1975)

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