EFFECTS OF DROUGHT AND HEAT ON BARLEY AND MALT: OUTCOME AND POSSIBLE REMEDIES

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OVERVIEW FOR 2021IN NORTH AMERICA

- Severe weather has occurred in the barley growing regions of the US and Canada.
- It has had an effect on malting barley production—as well as other crop production.
- Brewers are wondering about effects on the malt they will purchase in the coming year.
- This presentation will review stress, its effect on the malt, the beer, and what brewers can do.

- What to expect?

It all depends…

MANY FACTORS, MANY VARIABLES

Many factors to consider:

In this presentation, we will consider stress caused by heat or drought. But the result is not always the same.

There are many factors to consider and they influence the result:

1. The type of stress:
    - Heat
    - Drought
    - Heat + Drought
2. Location—growing area or region
3. Growing conditions—dry land or irrigated
4. Barley type: 2-row or 6-row
5. Spring barley or Winter barley and the many varieties of each
6. Drought occurrence (When did it happen?) Timing in the growth cycle
7. Weather: Rain during harvest (Pre-harvest sprouting)
8. What can a brewer do? Options for handling the difficult situation

1. THE STRESSES ON THE GROWING BARLEY

1. Drought 

The impact from drought depends upon the length of drought, the severity (shortfall of moisture), and when it occurs during growing cycle.

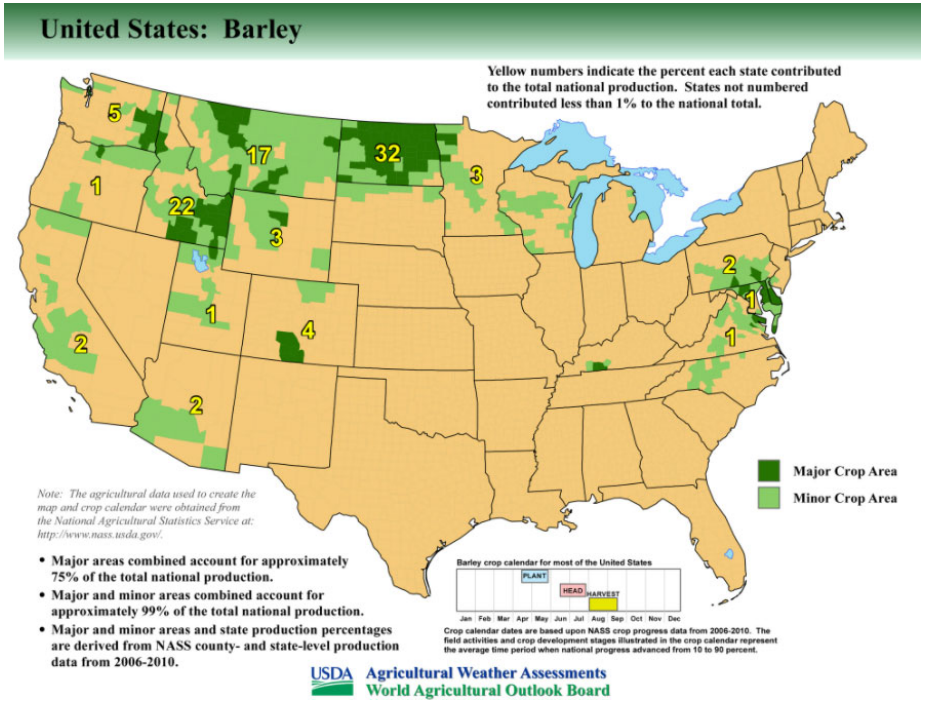
2. Heat 

Generally results in reduced grain weight (thinner kernels) and reduced starch (higher protein).

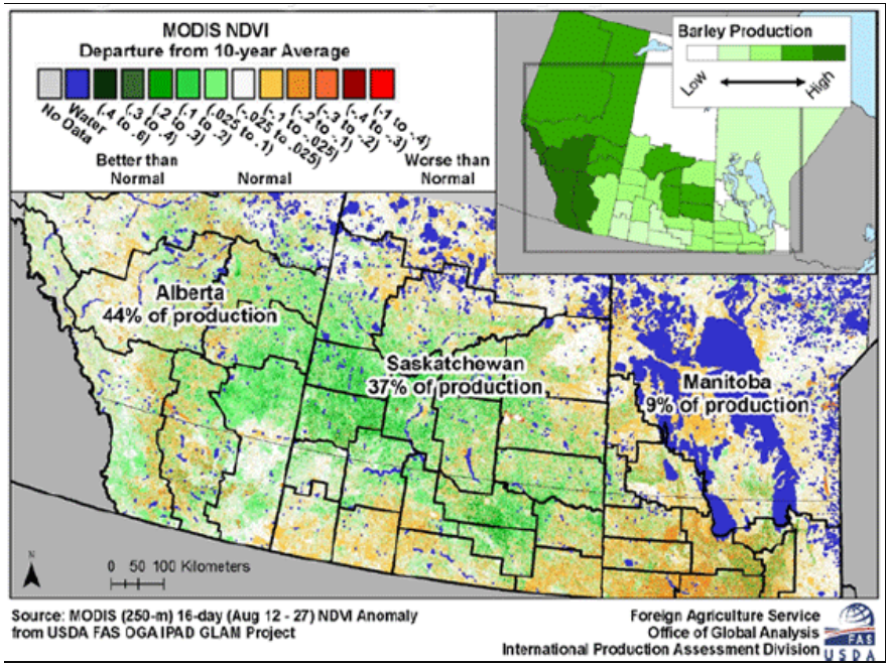

3. Drought + Heat

The stress from this combined effect is greater than the sum of these factors.

2. LOCATION



Barley growing regions of the US.
Source: https://www.usda.gov/oce/commodity-markets/waob



Barley growing regions of Canada.
Source: https://www.fas.usda.gov/data

EFFECT OF LOCATION

Note the difference of beta-glucan levels in samples grown in different Canadian provinces.

Table 4.1 Quality data for 2016 harvest survey composite samples of CDC Copeland malting barley[1]

Origin of selected samples	Alberta		Saskatchewan		Manitoba	Prairie Provinces		
Crop year	2016	2015	2016	2015	2016	2016	2015	2011-2015 Average
Tonnage[2], thousand of tonnes	481	261	232	290	38	761	551	336
Wort								
Fine grind extract, %	81.1	80.2	81.1	80.3	81.8	81.2	80.2	80.6
Coarse grind extract, %	80.5	79.3	80.7	79.6	80.9	80.6	79.4	79.7
F/C difference, %	0.6	0.9	0.5	0.7	0.9	0.6	0.8	0.8
ß-Glucan, ppm	105	48	69	41	68	92	44	65
Viscosity, cP	1.43	1.43	1.41	1.43	1.42	1.42	1.43	1.43
Soluble protein, %	4.39	4.73	4.75	5.11	4.92	4.52	4.93	4.88
Ratio S/T, %	40.1	39.6	41.9	42.7	43.9	40.8	41.2	42.0
FAN, mg/L	202	217	223	234	234	209	226	205
Colour, ASBC units	1.91	2.06	2.32	2.31	2.17	2.04	2.19	2.19

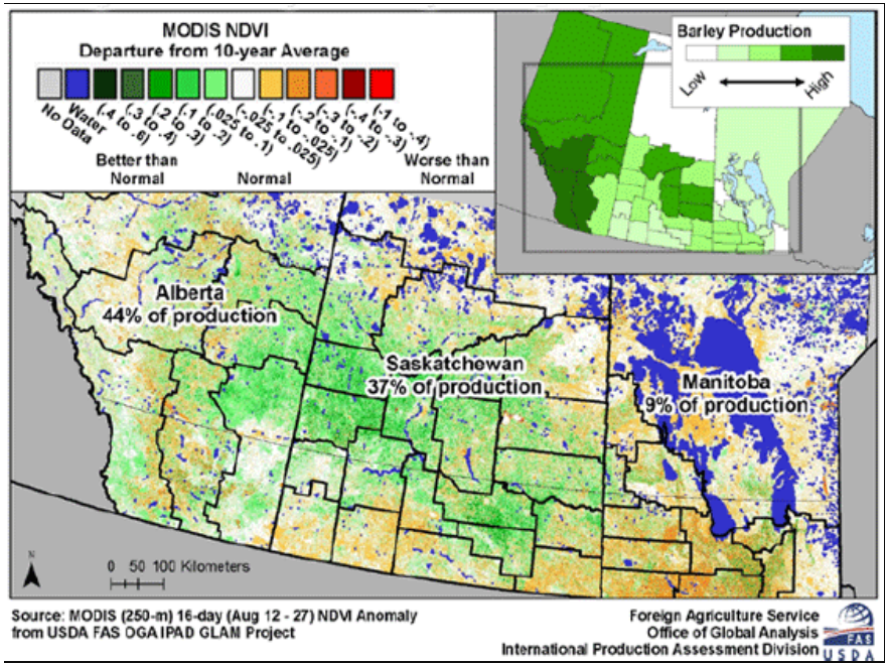
Beta glucan levels in wort from variety CDC Copeland, 2016 harvest.

Source: https://www.grainscanada.gc.ca/en/grain-research/export-quality/cereals/malting-barley/2016/05-quality-data.html

3. GROWING CONDITIONS-DRY LAND OR IRRIGATED

Western US barley growing areas. Areas shown are irrigated.

Source: Coors et al (1989) Malting at coors: one pound to 250 tons MBAA TQ v 46



Barley growing regions of Canada. Areas shown are dry-land.

Source: https://www.fas.usda.gov/data

4. BARLEY TYPE: 2-ROW OR 6-ROW

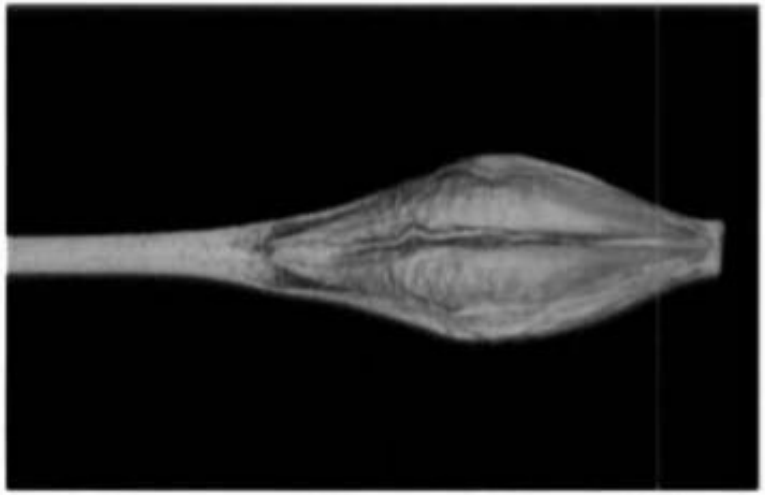


Fig. 1. Two-row malting type kernel with long-haired rachilla.

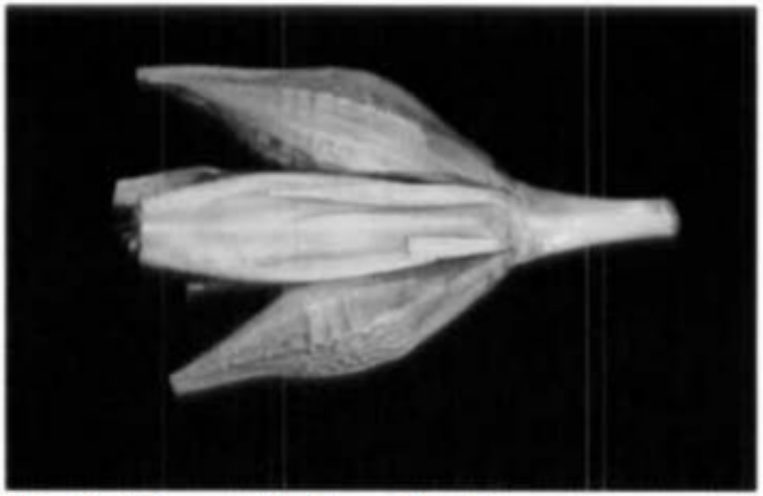


Fig. 2. Six-row barley showing arrangement of lateral and central spikelets.

The different types of barley can react differently to stress.

Source: Coors et al (1989) Malting at coors: one pound to 250 tons MBAA TQ v 46 pp 14-18

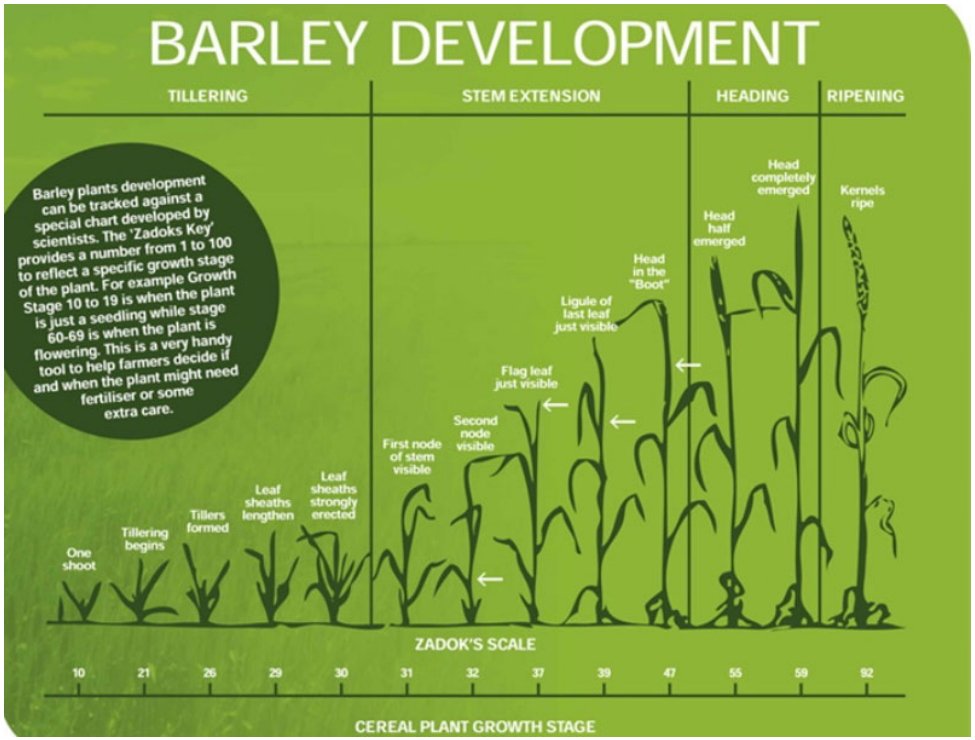
5. SPRING BARLEY OR WINTER BARLEY

There are many varieties of barley and each one will react differently to the same stress.
Not the amount of 2-row, both Spring and Winter varieties, as well as 6-row, both Spring and Winter varieties.

Approved 2- Row Varieties	Approved 6-Row Varieties
Spring:	**Spring:**
AAC Connect, AAC Synergy, ABI Eagle, ABI Growler, ABI Voyager, AC Metcalfe, Bill Coors 100, CDC Copeland, Conlon, Conrad, Expedition, Explorer, Hockett, LCS Genie, LCS Odyssey, Mayflower, Merit 57, Moravian 37, Moravian 69, Moravian 164, Moravian 165, Moravian 170, Moravian 179, ND Genesis, Newdale, Pinnacle	Celebration, Innovation, Lacey, Legacy, Quest, Tradition
Winter:	**Winter:**
Charles, Endeavor, Flavia, LCS Violetta, Puffin, Thunder	Thoroughbred

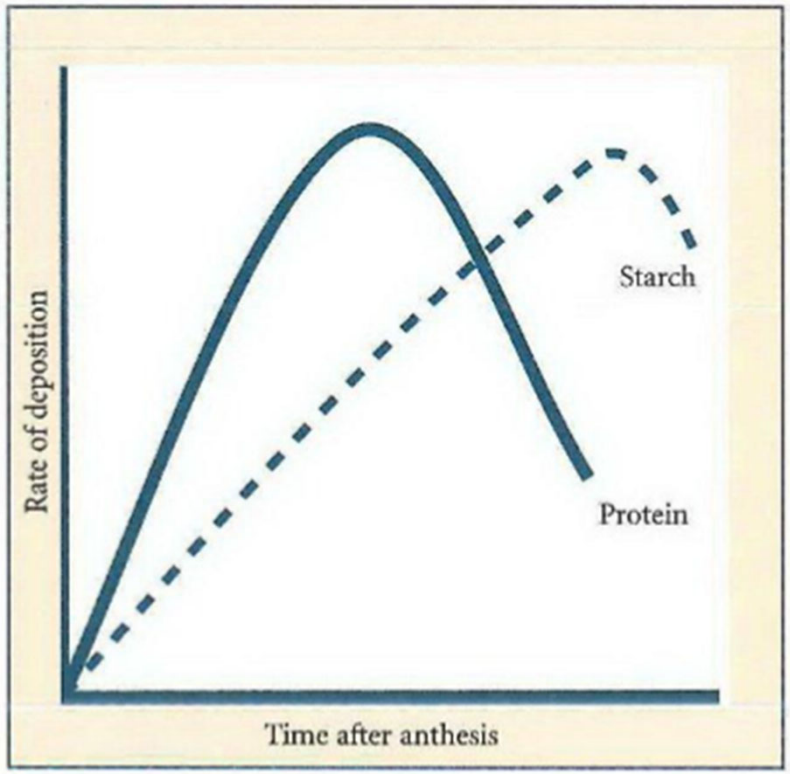
Source: American Malting Barley Association https://ambainc.org/amba-publications/recommended-malting-barley-varieties/

6. DROUGHT OCCURRENCE (WHEN DID IT HAPPEN?)



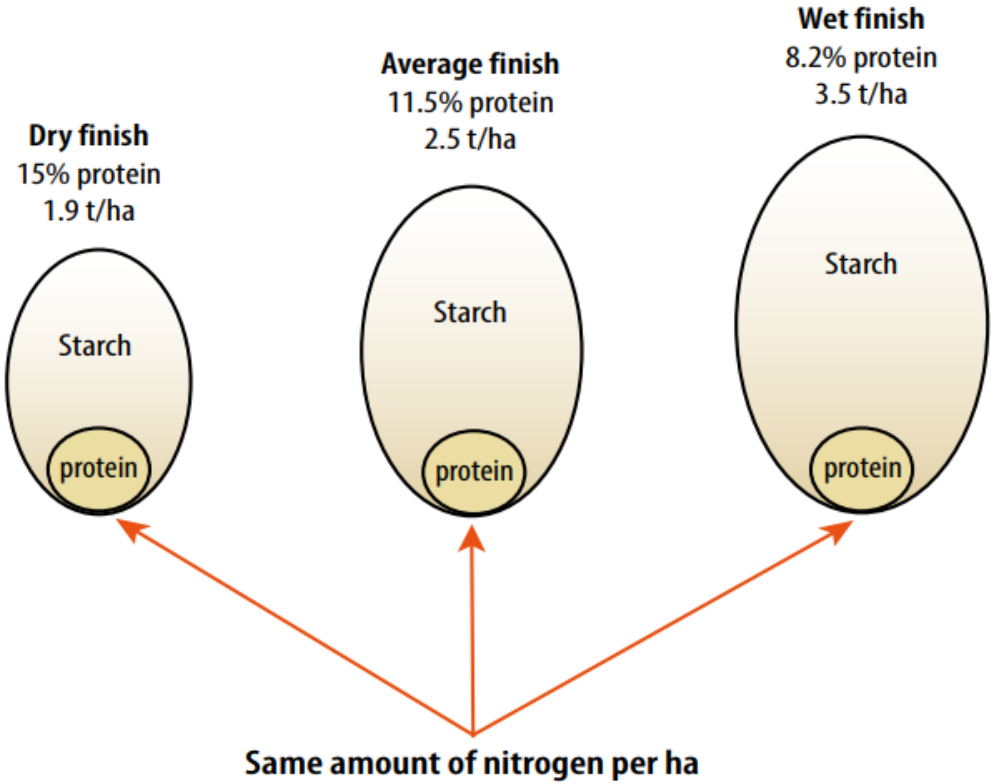
The relationship between barley development and build up of nutrients. (Not to scale)

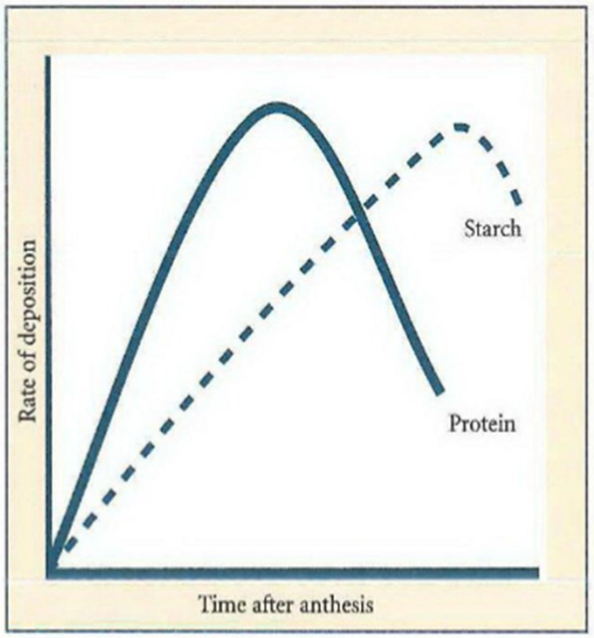
Source: http://thshsarchibull.blogspot.com/p/field-to-food.html



Young K, Howes M (eds) 1995, The Barley Book.

RELATIONSHIP BETWEEN PROTEIN AND STARCH



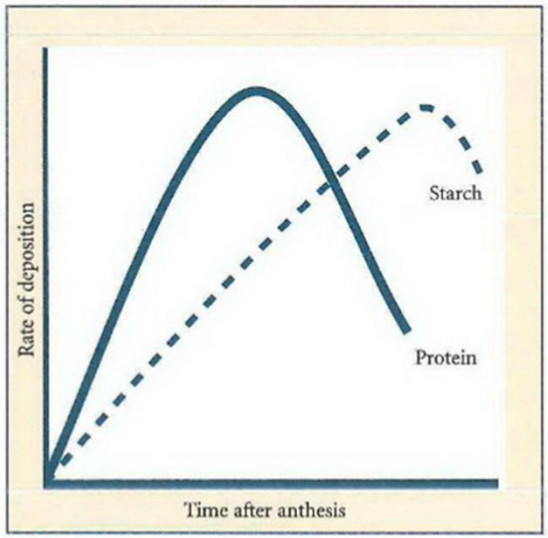


Young K, Howes M (eds) 1995, The Barley Book.

Protein percentage related to the amount of starch.

Source: https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0003/516180/Procrop-barley-growth-and-development.pdf

COMMON SCALES FOR PLANT GROWTH



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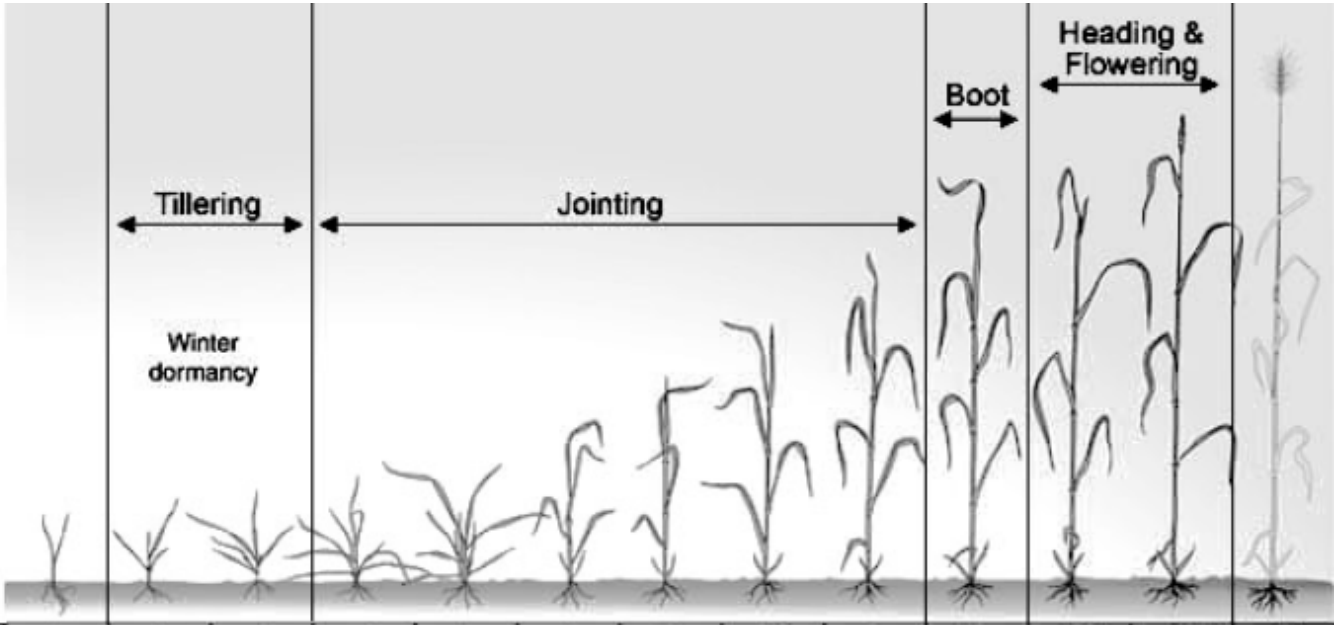
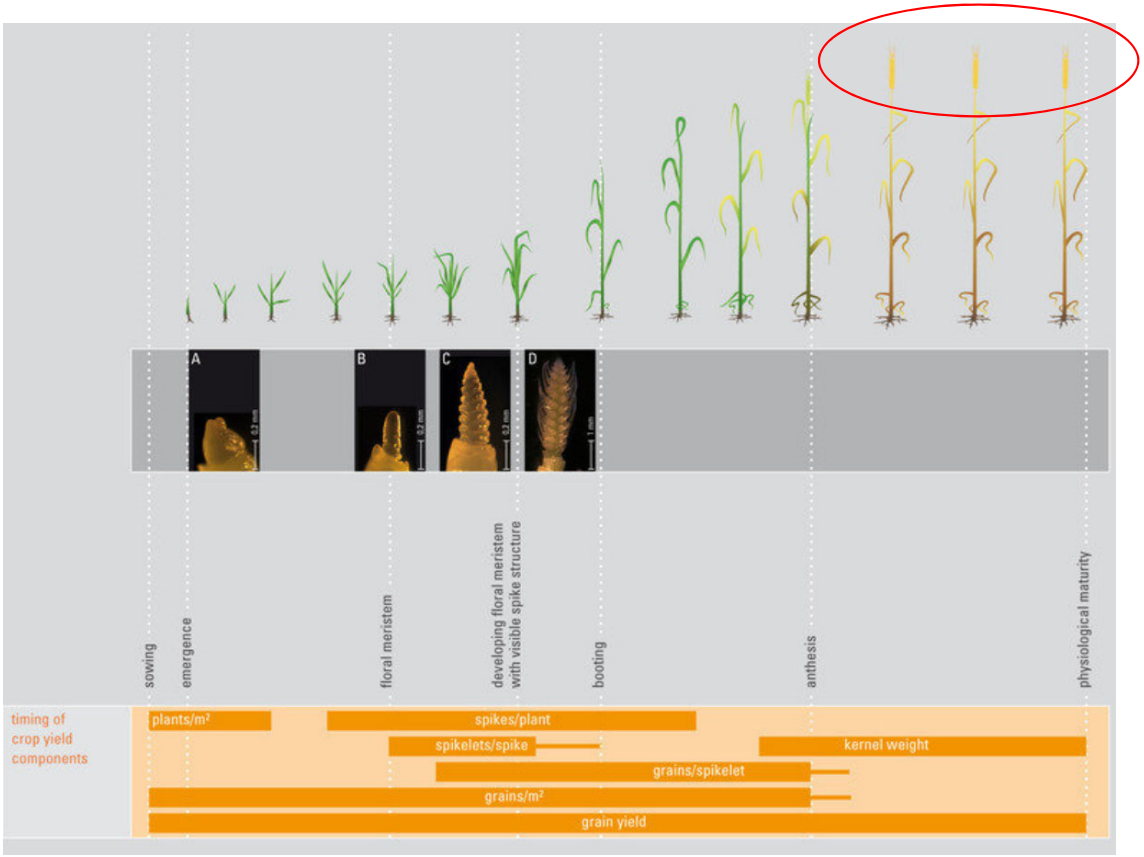


Feekes	1	2	3	4	5	6	7	8	9	10	10.1	10.5	11
Zadoks	10	21	26	30	30	31	32	37	39	45	50	60	90

Two common scales used to describe plant growth. These scales help farmers to determine when application of nutrients and other treatments are necessary.

Source: https://nrcca.cals.cornell.edu/crop/CA2/figures/WheatFeekes.jpg

GROWTH STAGES OF BARLEY



Source: https://www.mpipz.mpg.de/5431/news_publication_897267

7. WEATHER: PRE-HARVEST SPROUTING

1. Pre-harvest sprouting is caused by rain prior to harvest. The barley kernels begin to germinate on the plant.

   Dormancy in the grain prevents this from happening, but it has been bred out of most barley varieties grown for malting today.

2. Pre-germinated barley results in reduced embryo viability and reduced germination in malthouse.

3. With no viable embryo, no enzymes are produced during steeping and germination.

4. Difficult to separate viable and non-viable grains.

5. This results in high levels of beta-glucans in the malt and in the wort.
(Kapp, C., 2019)

Sweeney, D., 2019

MALTING BARLEY EVALUATION

This table shows barley parameters important for malting.
Note indicators for well-developed grain, including Test Weight, 1000 kernel weight (TKW), Plump/thins, and Protein.
Plump >6/64" = >2.5 mm
Thins >5/64" = >2.0 mm

Barley grown in N America will tend to have a slightly higher protein.

Table 5.1 Quality data for CDC Copeland malting barley[a]

Origin of selected samples	Alberta		Saskatchewan		Manitoba		Prairie Provinces		
Crop year	**2020**	2019	**2020**	2019	**2020**	2019	**2020**	2019	2015-2019 average
Number of samples	**12**	16	**17**	14	**4**	2	**33**	32	
Tonnage represented by samples (thousands of tonnes)[h]	**324**	357	**655**	448	**53**	18	**1,032**	823	916
Barley									
Test Weight (kg/hL)	**67.1**	66.0	**66.5**	66.1	**66.6**	66.4	**66.7**	66.1	66.8
1000 kernel weight (g)	**44.1**	44.1	**44.9**	46.3	**45.4**	44.4	**44.7**	45.3	46.4
Plump, over 6/64" sieve (%)	**90.5**	91.5	**91.7**	93.7	**91.6**	92.4	**91.3**	92.7	94.1
Intermediate, over 5/64" sieve (%)	**7.9**	7.0	**6.9**	5.0	**6.8**	6.4	**7.2**	5.9	4.5
Moisture[c] (%)	**10.8**	12.7	**11.8**	13.3	**10.6**	11.9	**11.4**	13.1	12.2
Protein (%, db)	**11.6**	11.5	**11.8**	11.3	**11.5**	11.3	**11.7**	11.4	11.5
Germination, 4 ml (%)	**100**	98	**99**	99	**99**	99	**99**	98	98
Germination, 8 ml (%)	**98**	93	**98**	93	**96**	95	**98**	93	93

Source: https://www.grainscanada.gc.ca/en/grain-research/export-quality/cereals/malting-barley/2016/05-quality-data.html

WHAT CAN A BREWER DO? RECOMMENDATIONS FOR OPTIMIZING (1)

Problem: HIGH BETA GLUCAN

Cause: High protein and pre-harvest sprouting

Result: Higher wort viscosity and longer lauter times, stuck mash, etc.

Potential for lower extract.

Pre-germinated barley is high in beta-glucan because the barley has not developed beta-glucanase to break down the cell wall beta glucans.

Higher proteins in the cell wall matrix mean that it is difficult for water to pass through the germinating kernel. This is known as “steely” malt. Some parts of the kernel will remain undermodified.

You may see lower “Friability” in your malt COA. This indicates lower level of modification. Low modification tends to see higher beta glucan.

Solution: Beta-glucanase to reduce beta glucans an reduce wort viscosity. Eliminate long run-off and stuck mash.

Product: LAMINEX® MaxFlow 4G, ALPHALASE® AP4

WHAT CAN A BREWER DO? RECOMMENDATIONS FOR OPTIMIZING (2)

Problem: HIGH PROTEIN

Cause: Drought and heat stress

Result: Higher beta glucan, lower extract. “Steely” kernels. Small starch granules.

Water does not travel as easily through high protein barley. This makes modification more difficult.

Under modified malt will have higher beta-glucan and lower extract.

There may be higher levels of enzyme, so a change in mash program may be necessary, with higher temps or shorter time.

Less beer stability / greater chance for haze formation.

More trub in whirlpool leading to more wort/beer losses.

May need more intense treatment to prevent haze, including carrageenan, isinglass, silica gel, PVPP.

Solution: Protease. Helps to break down endosperm cell walls. Provides access to starch for alpha amylase, provides access to cell wall for beta-glucanase.

Product: ALPHALSE® NP, ALPHALASE® AP4

WHAT CAN A BREWER DO? RECOMMENDATIONS FOR OPTIMIZING (3)

Problem: LESS EXTRACT

Cause: Drought and Heat Stress

Result: Less starch leading to lower levels of extract. More small starch granules in undermodified malt. Variable levels of alpha amylase.

1. Increase the amount of grist with additional malt. Do you have capacity in your mash tun or mash cooker?

2. Possible use of pre-gelatinized flakes (corn, rice, barley). From our experience, flakes need use of exogenous alpha amylase in the mash.

Watch out for the possibility of a higher gelatinization temperature in your malt.

- More small starch granules in the malt with a higher gelatinization temperature.
- Risk of starch in wort/beer Lautering and finish beer haze problems.
- Mash mixer not a problem, due to flexibility in temperature control.
- Problem for single infusion mash/lauter. Only one temperature practical.
- Exogenous alpha amylase will help produce more extract, helping to reach targets consistently. Temp not a problem.

Solution: Alpha-amylase

Products: AMYLEX® 6T, ALPHALASE® AP4

WHAT CAN A BREWER DO? RECOMMENDATIONS FOR OPTIMIZING (4)

Problem: LOW FERMENTABILITY

Cause: Lower extract, variable levels of alpha-amylase, beta amylase, higher strike temperature.

Result: Lower level of fermentability in finished beer.

1. Amount of alpha amylase and beta amylase in the malt is variable.
2. A higher strike temperature may be necessary to gelatinize small starch granules in undermodified areas of the malt.
3. But a higher temperature may denature beta amylase, the fermentability enzyme. It is heat sensitive.
4. There fore, fermentability may decrease.

Solution: Glucoamylase

Products: DIAZYME® TGA, ALPHALASE® AP4

FURTHER INFORMATION

MBAA Podcast

Episode 228: The Challenging 2021 Barley Outlook

https://www.masterbrewerspodcast.com/228

Brewers Association

From Barley to Beer, Managing Malt Quality in a Changing Climate

https://www.brewersassociation.org/collab-hour/from-barley-to-beer-managing-malt-quality-in-a-changing-climate/

*Membership required

CONCLUSION

1. Barley yields at harvest are down. Some estimates for the US indicate the smallest harvest since 1900. Lowest yields in 120 years!

2. There are many factors that effect the final barley quality and it means that the results are highly variable, too.

3. Talk to your maltster. This is the key person to help you understand what to expect.

At every harvest, maltsters take a variable raw material and turn it into a consistent product for you.

4. Talk to your Gusmer technical sales rep. This is your first point of contact for questions about enzymes to help in the brewing process.

THANK YOU!

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